SURVEY REPORT
OF
TRIBOROUGH BRIDGE AND TUNNEL AUTHORITY
RANDALL'S ISLAND
NEW YORK, NEW YORK 10035

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PURPOSE OF SURVEY:	The purpose of the industrial hygiene survey was to determine the Triborough Bridge and Tunnel Authority (TBTA) employees' exposure to carbon monoxide (CO), nitrogen dioxide (NO_2), polycyclic aromatic hydrocarbons (PAH's), and heavy metals (e.g., lead).
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DISCLAIMER

Mention of company names or products does not constitute endorsement by NIOSH.

ABSTRACT

An industrial hygiene survey was conducted at the Triborough Bridge and Tunnel Authority in conjunction with an epidemiological historical prospective mortality study on the bridge and tunnel offficers. In this survey, worker exposure to carbon monoxide and other air contaminants in the various toll tunnel and toll bridge environments was determined. Personal and area samples were collected for carbon monoxide (CO), nitrogen dioxide (NO_2), polycyclic aromatic hydrocarbons (PAHs), heavy metals, and asbestos.

No appreciable exposure via inhalation was found to nitrogen dioxide, polycyclic aromatic hydrocarbons or heavy metals. Most of the CO levels measured inside the plaza toll booths, tunnel observation booths, and above the canopy were well below the OSHA standard of 50 parts per million (ppm) and the NIOSH recommended standard of 35 ppm for an 8-hour Time Weighted Average (TWA). The geometric means for these locations ranged from 5.02 to 25.93. Hourly concentrations of CO found in the toll lanes (e.g. 89 and 94 ppm) and on the tunnel catwalks (e.g. 125 and 146 ppm) were frequently above the OSHA standard. However, most bridge and tunnel officers (BTOs) were not exposed to those levels for more than 1-2 hours at a time in the toll lanes and 5-15 minutes at a time on the tunnel catwalks.

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INTRODUCTION

Under the Occupational Safety and Health Act of 1970 (set forth by the 91st Congress, S.9123, Public Law 91-596) the National Institute for Occupational Safety and Health (NIOSH) was given the authority and responsibility for conducting and reporting on field research studies in industry. Section 20(a)7 states that NIOSH shall conduct and publish industrywide studies of the effects of chronic low level exposure to industrial materials, processes, and stresses on the potential for illness, disease or loss of functional capacity in the aging adult.

Automotive pollution produced by emissions from multiple mobile sources has become the major air pollution problem in most urban areas. Carbon monoxide, hydrocarbons, nitrogen oxides, particulates, and sulfur oxides which are generated by the gasoline-powered internal combustion engine are hazardous to human health.[1]

The major pollutant, however, is carbon monoxide (CO). In fact, the total emissions of CO exceed that of all other combustion products combined, except for carbon dioxide (CO_2).[2] Exposure of workers to CO has been determined to be a leading cause of occupational disease and death. It has been reported that between 1968 and 1975, CO caused 8,764 deaths in the United States; 5,782 of those deaths were attributed to motor vehicle exhaust.[3]

Although the effects of acute exposures to CO are well known (e.g., headache, nausea, dizziness, and death), controversy surrounds what effects chronic exposures to low levels (below 35 ppm) of CO have on workers. To help provide additional research data, NIOSH initiated an intensive effort to find an occupational facility that (1) consisted of employees who had been exposed to low levels of CO for a considerable length of time and (2) had maintained demographic and work history records on present and former employees. The Triborough Bridge and Tunnel Authority (TBTA) fulfilled both requirements, therefore, an historical prospective mortality study is being conducted.

As part of this epidemiologic study, an industrial hygiene survey was performed at TBTA in New York City on August 3-13, 1981, to determine the bridge and tunnel officers' (BTO's) exposure to CO, nitrogen dioxide (NO_2), polycyclic aromatic hydrocarbons (PAH's), metals (e.g., lead) and asbestos.[2]

BACKGROUND

The Triborough Bridge and Tunnel Authority built and operates nine major water crossings (two toll tunnels and seven toll bridges) in New York City, as well as two public garages, one parking field, an airlines terminal building, and the New York Coliseum.[4,5] (See Table 1.)

The Authority, a public benefit corporation functioning under the Public Authorities Law of the State of New York, was created in 1933. In 1968, the State unified the metropolitan transportation agencies into the Metropolitan Transportation Authority and TBTA became a constituent associate. As such, TBTA's annual net operating surplus is used to aid public transportation.

TABLE 1

TUNNELS AND BRIDGES OPERATED BY
Triborough Bridge and Tunnel Authority
New York City, New York

FACILITY	DATE OPENED	TOTAL TRAFFIC (1980)
Triborough Bridge	7-11-36	53,004,864
Verazanno-Narrows Bridge		47,110,749
upper level	11-21-64	
lower level	6-28-69	
Throgs Neck Bridge	1-11-61	33,800,843
Bronx-Whitestone Bridge	4-29-39	32,553,007
Queens Midtown Tunnel	11-15-40	24,846,735
Brooklyn-Battery Tunnel	5-25-50	20,519,184
Henry Hudson Bridge	12-05-36	11,020,921
Marine Parkway Bridge	7-03-37	7,251,270
Cross Bay Bridge	5-28-70	5,773,498

DESCRIPTION OF TRIBOROUGH BRIDGE

The TBTA facilities chosen for the industrial hygiene field study were those studied previously by Scott Research Laboratories, Inc., the Triborough Bridge and the Queens Midtown Tunnel.[6] The Triborough Bridge (TB) connects three of New York City's boroughs: Manhattan, Bronx, and Queens; spans the Harlem and East Rivers; and handles approximately 145,200 vehicles per day (1980)[5]. (See Appendix, Table A-1.) The bridge's three branches join to form an interchange on Randall's Island. This interchange houses both the Bronx and Manhattan toll plazas and toll plaza service buildings.

Both toll plazas are elevated and have no surrounding structures to block the natural flow of ambient air. A canopy approximately 15 feet wide x 200 feet long and 20 feet above the roadway covers 16 toll booths at each plaza.

Each toll booth has an internal working space approximately 3 feet wide, 6 feet long, and 7 feet high. There is a sliding door at the back and front of the booth and a swinging half-door about waist high with a vertical sliding plexiglass shield on the collection side of the booth.

The air intake for the toll plaza is located several feet above the canopy. Ambient air, which may or may not be heated, is drawn in and blown down a main duct which spans the top of the canopy. The ventilation air then flows through several 30° angle side ducts (which then bend at a 90° angle in relation to the canopy roof) into the booth ceilings and the sides of the door frames. Perforated plenums have been added to the booth ceilings to distribute the incoming ventilation air more evenly. The air flow rate for each booth is about 1,200 cubic feet per minute (cfm) or 570 air changes per hour.

DESCRIPTION OF QUEENS MIDTOWN TUNNEL

The Queens Midtown Tunnel (QMT) consists of two parallel tubes which connect two boroughs, Queens and Manhattan, and handle approximately 72,160 vehicles per day (1981).[5] (See Appendix, Table A-2.) The north tube is 6,420 feet long and carries west bound traffic from Queens to Manhattan. The south tube is 6,250 feet long and carries east bound traffic from Manhattan to Queens. During morning rush hours the south tube only is converted to two way traffic. Both tubes slope downward approximately 4% from each end towards the East River to a maximum depth of 94.5 feet below mean high water level.[7]

Ventilation for the tunnel tubes is provided from two ventilation buildings, one in each borough. The Queens building ventilates the Queen's portion of both tubes and the Manhattan building ventilates the remainder. Each tube is divided into four ventilation sections: S_1, S_2, S_3, and S_4 in the south tube, and N_1, N_2, N_3, and N_4 in the north tube. The tunnel ventilation flow rate is approximately 3,000,000 cfm resulting in a complete air change every 1½ minutes.

Eight Beckman nondispersive infrared analyzers (four in each ventilation building) monitor the CO concentration in all tunnel exhaust shafts and the CO levels are recorded on strip charts. The strip chart recorders are part of a large control panel that houses indicator lights for all tunnel ventilation fans. The control panel and computer, which operate the tunnel ventilation system, are located in the QMT plaza service building. When the computer is shut down for maintenance, the ventilation system is run manually (by the BTOs). Carbon monoxide is monitored to control the speed and number of exhaust and blower fans being operated.

The QMT has two entrance/exit points, one in Queens and one in Manhattan. However, there is only one toll plaza which is located in Queens; tolls are collected when traveling from Queens to Manhattan and upon returning to Queens from Manhattan.

The Queens Midtown toll plaza consists of 14 tolls booths covered by a canopy. (See Description of TB.) The plaza is located on a downgrade several hundred feet from the mouth of the tunnel. To the north of the plaza is a wall, several residences, and the plaza service building. To the south are several 3-4 story buildings and the toll booth ventilation building. Since the tunnel toll plaza is surrounded by structures and sloping roadway, natural ventilation is restricted.

The main intake for the toll plaza ventilation is located near the top of the southwest side of the plaza ventilation building. The height of the intake allows for mixing and dilution of auto exhaust with the ambient air. A fan pulls the air into the top of a room containing an automatic roll filter which extends from the ceiling to the floor. This filter removes most of the larger non-respirable particles from the air and is changed approximately every three months, or more often depending on its rate of use. Behind the roll filter are 12 box filters which remove smaller particles at an 80-85% efficiency, these filters are also changed approximately every three months. There is an additional 20" x 25" x 2" fiberglass filter in a fan unit heater which filters the intake air in the ceiling of each toll booth.

The ventilation intakes for the tunnel and the tunnel observation booths consist of three floors of louvered openings starting approximately 20-25 feet above the roadway, in the north and south sides of each tunnel ventilation building. There is no filtration system for this ventilation air. Each observation booth has is own fresh air duct and two separate 525 cfm (in fresh air ducts) blowers which give an overall booth air flow rate of approximately 1000 cfm.

DESCRIPTION OF EMPLOYEES' UNION

The union representing the bridge and tunnel officers is the Bridge and Tunnel Officers Benevolent Association (BTOBA). The BTOBA is an agency shop which requires that union dues be deducted from the officers' pay whether they are members of the union or not. Sergeants and uniformed toll lieutenants are members of the Sergeants and Lieutenants Benevolent Association; plain clothes lieutenants who are assistant facility supervisors and facility supervisors are not members. Several union delegates are located at each TBTA facility.

DESCRIPTION OF WORKFORCE

The Triborough Bridge and Tunnel Authority employs 1,133 full-time workers and 227 temporary and seasonal workers. Job categories and numbers of full-time employees are as follows:

Administrative and Clerical	126
Toll Collection and Traffic Control	731
Bridge and Tunnel Maintenance	170
Maintenance of Building, Plaza and Garages	106
TOTAL (Full-Time Employees)	1133

Of the 958 employees in the toll collection and traffic control group, there are 624 bridge and tunnel officers (BTO's), 57 sergeants, 50 lieutenants, and 227 temporary and seasonal employees. Ninety-eight and one-half percent of the BTO's are male; 1.5% are female, and 21.8% of all BTO's are minorities.

The distribution of officers at the two facilities sampled is:

Rank	Triborough Bridge	Queens Midtown Tunnel
Facility Supervisor	1	1
Lieutenants	4	4
Sergeants	11	4
Officers	117	121

There is shift rotation among the officers; also, sergeants rotate shifts every week and periodically are relocated at different facilities.

Both facilities are open 24 hours a day, 7 days a week. The number of shifts and BTOs per shift vary throughout the week due to predetermined daily fluctuations in traffic flow. For example, there are 9-10 overlapping shifts with 56-69 officers per day at the Queens Midtown Tunnel, and 7-9 overlapping shifts with 61-73 officers per day (both plazas) at the Triborough Bridge.

DESCRIPTION OF WORK DUTIES

Duties of the officers stationed at the TB include toll collection, lane patrol, traffic direction, law enforcement, and desk duties. In addition, the duties of the officers stationed at the QMT include observing tunnel traffic from tunnel observation booths and TV monitors in the service building, and transporting officers by posting van to and from tunnel posts. Two to three officers are also assigned to garage detail which includes operation of tow trucks.

At the beginning of each shift, the BTOs receive their post assignments for the day from a lieutenant or sergeant in the plaza service building. Those assigned to tunnel duty assemble in a posting van behind the toll plaza. The van leaves the plaza area at 10 minutes to the hour, every hour, each day between 6:00 a.m. and 12:00 midnight. All tunnel traffic is stopped while the officers exit/enter the posting van to change tunnel posts. After the tunnel posts are filled, the posting van is returned to the plaza.

From the tunnel booths, the officers observe traffic slowdowns and stoppages, vehicle breakdowns, and accidents. When one of the above occurs, the officer may leave the booth to direct traffic or assist in an emergency situation.

The tunnel traffic flow is also monitored by several cameras located above the tunnel roadway and is viewed on several TV monitors at the desk in the plaza service building. A record is kept of all traffic slowdowns or stoppages, why they occur, the section(s) of the tunnel and lanes where they occur, and length of time needed to clear the lane. If the computer that operates the tunnel ventilation system is shut down, the BTOs must also monitor the CO strip charts and manually operate the ventilation system.

At both the tunnel and bridge toll plazas, the officers may either sit or stand at the toll booth half-door while collecting tolls. If there is a problem or emergency, the officer sounds a bell or buzzer and turns on a light located near the top of the canopy. The officer patrolling the lanes knows by the sound (buzzer or bell) which end of the plaza to go, and by the light the particular booth where his assistance is needed. The officers patrolling the lanes or directing traffic may also issue traffic tickets and make arrests.

Schedules for these duties are prepared jointly by the Union and TBTA Operations Division Management. Although the duty schedules change daily, all officers stationed at the TB and QMT (except those assigned to tunnel duty) receive two 20-minute breaks, one 50-minute meal period, and one 30-minute air-relief (break) daily. Those assigned to tunnel duty receive one 60-minute air-relief and one 60-minute meal period daily. An additional break may be scheduled for the officers assigned to tunnel duty if, upon leaving tunnel duty, they are not needed to relieve the officers taking tolls or directing traffic.

Air-relief is an extended break; an officer leaves the plaza or tunnel and enters the service facility building to relax and to decrease his exposure time to vehicle exhaust. An officer must work for at least 1 hour, but no longer than 2 hours, before receiving a break. Also, officers are never assigned to tunnel duty for more than 2 hours at a time, or for more than two tours of 2 hours each in any one day.

DESCRIPTION OF INDUSTRIAL HYGIENE, SAFETY AND MEDICAL PROGRAMS

Industrial Hygiene

TBTA does not have an industrial hygienist or an organized industrial hygiene program; however, carbon monoxide (CO) levels and ventilation flow rates are constantly being monitored inside the toll tunnels.

In 1979, TBTA replaced eight MSA Hopcolite CO analyzers at the QMT with Beckman non-dispersive infrared CO analyzers. This was done to improve the performance of the computer controlled ventilation fans which are adjusted to control tunnel CO concentrations.

Safety Program

The safety program is under the direction of the Safety Director, Administrative Engineer, M. Richard Shubar. Safety meetings are held by the supervisors several times a year. At least one safety delegate, appointed by the union, is located at each of the nine facilities.

When initially employed, the officers are issued uniforms which resemble those of the New York City Police Department; thereafter, the officers receive a uniform allowance. Personal protective equipment and clothing includes the following: Scott air pack and asbestos gloves which are stored on the tunnel emergency tow trucks; riot helmets, 2-way radios, flashlights, and shoes with non-skid soles are issued to the BTOs. The toll plaza service buildings at the QMT and TB contain a lunch room, lockers, clothing change area, showers, and rest rooms. There are separate facilities for men and women at the QMT.

Educational posters regarding job safety are posted periodically, and safety manuals and operating procedures manuals are provided as well as lectures (on a voluntary basis) on first aid every 3 years and on fire fighting every 2 years. A hearing conservation program that meets OSHA requirements was to be implemented for BTOs around March 1, 1983. All bridge and tunnel officers are required to participate in a training program that includes: toll training, fire fighting, law enforcement, and first aid.

Reported number of injuries on duty totaled 578 in 1979 and 733 in 1980.[8] These included smoke inhalation from fires and injuries to various parts of the body (e.g., eyes, fingers, toes, and legs) due to falls, being struck by vehicles, etc.). If an injury is severe, e.g., being hit by a car, the officer may receive compensation from the Authority for up to one year; this may be extended by using annual and/or sick leave. Long-term disability benefits may also be received which consists of 70% of the officers annual pay less any fringe benefits.

Medical Program

The Authority employs the Queens Professional Group to conduct a complete pre-employment physical examination. The pre-employment examination includes: medical questionnaire, electrocardiogram (ECG), spirometry, visual acuity, chest x-ray, urinalysis, blood pressure measurement, complete blood count (CBC), SMAC (Sequential Multiple Analyzer Computer, blood profile), and blood lead level. However, until 1973, the pre-employment physicals were handled by the New York City Department of Personnel. These examinations were very limited and inadequate compared to the present pre-employment physicals.

TBTA also employs two physicians who are on call for illnesses and injuries. Dr. Caruso conducts general medical examinations (e.g., heart conditions and BTOs' injuries due to accidents); Dr. Koval conducts the orthopedic examinations of BTOs' receiving injuries on duty (e.g., back and feet).

Annual physical examinations are optional and are conducted in the St. Vincent Hospital's mobile laboratory (van) which travels to each TBTA facility. The van is used by Steven M. Ayres, M.D., who was contracted by the TBTA to continually observe the health of the BTOs, especially pulmonary function. In case of an emergency, officers are taken to the hospital nearest their assigned location.

POTENTIAL EXPOSURES AND CONTROLS

Some of the chemical exposures associated with bridge and tunnel work are to carbon monoxide (CO), hyrodcarbons, aldehydes, particulates, heavy metals, nitrogen oxides and sulfur oxides. These exposures occur while the BTOs are collecting tolls, directing traffic, patrolling toll lanes, driving, and walking inside the tunnel.

Inhalation is the major route of entry to the body for vehicular exhaust components. Ventilation is used as a control measure in the tunnel, tunnel observation booths, and toll booths. (See sections on TB and QMT for flow rates.) No personal protective equipment is used.

DESCRIPTION OF PAST EXPOSURES

The first tunnel observation booths were constructed by the Authority's maintenance personnel during the mid to late 1940's. These booths had no forced air ventilation. During the late 1960's, these booths were replaced and supplementary forced-air ventilation was added. During the construction period from 1969 to June, 1970, however, the new plexiglass booths had loose fitting wood doors which allowed auto exhaust to enter. The replacement booth doors were made of plexiglass and provided a tight seal with the booth.

Prior to February 27, 1968, it was mandantory that the BTOs assigned to tunnel duty stand on the catwalk during rush hours with only a wind shield between them and the traffic. Factors which could have increased the BTOs' CO exposure during rush-hour tunnel duty prior to 1968 were: increase in number of vehicles, backup and queuing of vehicles through and outside of the tunnel (idling engines produce more CO than faster running engines), nonexistence of the catalytic converter, and manual operation of tunnel exhaust and blower fans.

Also, prior to September 1, 1971, there was no forced-air ventilation inside the toll plaza booths at the Queens Midtown Tunnel; and at the Triborough Bridge the ventilation system intake was located underneath the canopy. Therefore, it was possible for the CO from the auto exhaust to accumulate in or be blown into the toll booths.

On February 11, 1959, an internal TBTA memorandum was forwarded to the Engineer of Maintenance regarding the TBTA carbon monoxide tapes for 1958 from the QMT and BBT (Brooklyn Battery Tunnel). Table 2 provides the CO data contained in that memo.

TABLE 2
TBTA CO MONITORING TAPE DATA
FOR 1958

Tunnel Section	# of Times CO Exceeded 250 ppm	Total Time (min) CO Exceeded 250 ppm	Highest CO Readings (ppm)
Queens N_1	2	32	405
Queens N_2	13	61	330
Manhattan N_3	2	15	280
Manhattan N_4	13	78	320
Queens S_1	46	250	370
Queens S_2	14	93	345
Manhattan S_3	61	249	390
Manhattan S_4	6	31	285

In 1961, at the request of the Authority, the Guy B. Panero Company conducted a ventilation investigation and atmospheric sampling program at the QMT and BBT. First, a profile of CO concentration was obtained by taking CO readings every 200 feet (inside the tunnels) with a Mine Safety Appliances (MSA) field CO analyzer. The Authority's CO recording tapes were studied and it was found that the number of consecutive 8-hour periods during which the CO concentration exceeded 100 ppm was 115 out of 252 or 45.6% in section N_3 and 2% in section S_3. From this information, the exact times and locations for sampling were chosen. Twenty-four hour sampling was conducted at the QMT, section N_3, on Friday, February 22, 1961, and Friday, July 28, 1961. The sampling equipment consisted of a 250 mL gas sampling tube in series with a train of absorption bottles, gas meter, and pump.

The Panero study[7] revealed that the 24-hour average CO concentration (taken from TBTA's CO recording tapes) at QMT was 53 ppm (summer day) and 49 ppm (winter day) for the days sampled. Peak CO values ranged from 200-290 ppm in the summer and 100-200 ppm during the winter. (The lower values were taken from Panero's data; the higher values from the TBTA CO recording tapes).

The highest carboxyhemoglobin (COHb) level for the QMT BTOs was predicted to be 13%. (The 1960 threshold limit value (TLV) for CO was 100 ppm for an 8-hour day which was equivalent to a blood COHb level of approximately 13%). Levels of oxides of nitrogen were below the TLV of 5 ppm. Panero concluded that the air intakes, ventilation equipment, and CO recording equipment were adequate and functioning properly.

In July 1968, Konstandt Laboratories, Inc., of New York, was retained by TBTA to determine the CO content of air in operating toll booths at several TBTA toll plazas. Samples were taken from 8:00-9:15 a.m. and 5:00-6:00 p.m., July 25, 26, 29, and 30, 1968. The readings were taken in the center of the booths and in the toll plaza approximately 200-300 feet away from the toll booths by using the Pyrotannic Acid Method.[9] The CO levels found at QMT & TB may be found in Table 3.

TABLE 3
CO SURVEY DATA OBTAINED AT TBTA BY KONSTANDT LABORATORIES (1968)[10]

CO Concentration - QMT

Sampling Time	Booth 5	Plaza
8-9:15 a.m.	165 ppm 120 ppm	20 ppm
	Booth 10	Plaza
5-6:00 p.m.	145 ppm 65 ppm	22 ppm

CO Concentration - TB Manhattan Plaza

	Booth 4	Booth 10	Plaza
8-9:15 a.m.	35 ppm 15 ppm	40 ppm 22 ppm	None found
5-6:00 p.m.	18 ppm 12 ppm	-	3 ppm

CO Concentration - TB-Bronx Plaza

	Booth 9	Plaza
8-9:15 a.m.	45 ppm 20 ppm	5 ppm
	Booth 3	Plaza
5-6:00 p.m.	22 ppm 14 ppm	5 ppm

In 1968, TBTA also retained Guy B. Panero, Inc., to establish a CO profile of the air in plaza toll booths[11] and to verify Konstandt's previous report. Panero retained the Travelers Research Corporation, an Air Resource and Environmental Studies Agency, to assist in establishing a CO profile of the air in one entrance and one exit toll booth on each plaza for a 24-hour period. The CO levels may be seen in Table 4.

TABLE 4
CO SURVEY DATA OBTAINED AT TBTA BY
GUY B. PANERO, INC. (1968)

CO Concentration

QMT Lane 9, Manhattan to Queens

Date		Range
February 26, 1968 Wednesday afternoon & evening		25-45 ppm
After midnight		10-20 ppm
February 27, 1968 Thursday morning		20-30 ppm
QMT Lane 4, Queens to Manhattan		
February 27, 1968 Thursday evening		10-20 ppm
February 28, 1968 Friday morning		30-40 ppm
QMT - Canopy		
February 27, 1968	3 feet above canopy	3-5 ppm
Thursday	10 feet above canopy	4 ppm

Panero's second study found levels of CO (measured over 24-hours) averaging 24-26 ppm at lane 4 and 9. However, CO concentrations of 30 to 40 ppm on an hourly average might exist for several hours at a time. CO concentrations measured 3 feet and 10 feet above the toll plaza averaged 3-5 ppm.

On June 4, 1970, Scott Research Laboratories, Inc. was retained to conduct a comprehensive series of air quality tests in and around two TBTA facilities, QMT and TB. Prior to the formal study, three months of preliminary CO sampling was conducted at the QMT from August 14 - October 16, 1970, in the toll booths and on top of the toll plaza canopy. A Beckman nondispersive infrared analyzer was used to sample for CO; the results obtained may be seen in Table 5.

TABLE 5

PRELIMINARY CO SURVEY DATA OBTAINED AT TBTA BY
SCOTT RESEARCH LABORATORIES (1970)

Date	Location	CO Average (ppm)	CO Range (ppm) (for Aug.-Oct)
August, 1970	Toll booth 7	36.5	15.8 - 77.0
	Above Canopy*	12.1	5.5 - 46.0
September, 1970	Toll booth 7	43.4	
	Above canopy*	13.3	
October, 1970	Toll booth 7	61.9	
	Above canopy*	13.5	

* Over Toll Booth 7

The formal study[6] conducted by Scott Research Laboratories at TBTA consisted of sampling for CO, total hydrocarbons, total oxidants, nitrogen oxides, NO_2, total aldehydes, acrolein and various particulate parameters. The sampling was conducted for 38 days at the QMT toll plaza, 8 days inside the QMT, and 38 days at the TB-Manhattan toll plaza. The results may be seen in Table 6.

TABLE 6

CO SURVEY DATA OBTAINED AT TBTA BY
SCOTT RESEARCH LABORATORIES (1970)

Date	Location	CO Average (ppm)	CO Range (ppm)
Oct. 19-31, 1970	Booth 7	77.3	55-104
	Canopy*	15.2	-
Nov. 1-25, 1970	Booth 7	55.4	23-102
	Canopy*	27.2	-
Dec. 16-23, 1970	Tunnel Catwalk	41.1	-
	Catwalk booth (S-10)	7.5	-

* Oct. 19-28 sampling probe was above the canopy; Oct. 29 - Nov. 25 sampling probe was below the canopy.

TB - MANHATTAN PLAZA

Date	Location	CO Average (ppm)	CO Range (ppm)
Jan. 15-31, 1971	Booth 9	12.6	4-32
	Canopy	16.8	-
Feb. 1-21, 1971	Booth 9	13.7	5-25
	Canopy	8.2	-

During November, 1972; October, 1973; and June, 1975, the New York State Department of Labor conducted industrial hygiene sampling for CO at the TB-Manhattan Plaza. The purpose of the 1972 field investigation was to check the recently installed plaza toll booth ventilation system. However, final adjustments in the ventilation system had not been completed at the time of the investigation. At the time of the 1975 survey, perforated plenums had been installed in the plaza toll booth ceilings. The results of all three surveys may be seen in Table 7.

TABLE 7

CO SURVEY DATA OBTAINED AT TBTA BY NEW YORK STATE DEPARTMENT (1972, 1973, AND 1975)

Date	Shift	Location	CO TWA (ppm)	CO Range (ppm)	Temp. F	Relative Humidity (%)
			TB - Manhattan plaza			
11/22/72	3-11 pm	Booth 5	12	0-40	26-32	51-63
10/31/73	3-10 pm	Booth 5	12	0-60	58-67	42-75
			TB - Bronx Plaza			
10/31/73	7-8 am	Booth 10	11	0-210	46-63	38-76
			TB - Manhattan Plaza			
6/4/75	2-4:30 4:30-6:30 pm	All Manned Booths	6-14 6-18	6-40	61-62	97

In 1977, Scott Environmental Technology, Inc., (formerly Scott Research Labs., Inc.) was again retained by TBTA to conduct air sampling at all of the bridges and tunnels. The results[12] from the CO sampling conducted at the QMT and TB may be found in Table 8.

TABLE 8

CO SURVEY DATA OBTAINED AT TBTA BY SCOTT ENVIRONMENTAL TECHNOLOGY, INC. (1977)

Date	Location	CO Average (ppm)	CO Range (ppm)
		QMT	
July 13-15, 1977	Booth 4	9.0	2.9 - 18.3
	Booth 7*	11.8	2.6 - 28.9
		TB - Bronx Plaza	
August 21-29, 1977	Booth 5	8.6	1.0 - 22.1
	Booth 10	5.5	1.3 - 15.4

* NO_2 sampling was conducted at QMT, Booth 7, on July 15, 1977, and averaged 0.14 ppm over 3 hours.

TB - Manhattan Plaza

August 29-31, 1977	Booth 5	8.0	2.6 - 18.7
	Booth 12	5.9	1.4 - 10.2
Sept. 1-6, 1977	Booth 5	6.5	1.5 - 19.8
	Booth 12	5.6	1.4 - 18.0

In 1979, TBTA contracted with Bolt Beranak and Newman, Inc. to conduct a noise study at several TBTA facilities. The noise study showed that noise levels found on the QMT catwalk varied (depending on area and time of day) from 94-101 dBA.[13] These levels were above the OSHA standard[23] of 90 dBA for the 8-hour TWA and would be encountered by the BTOs upon leaving the tunnel observation booths to assist in handling traffic problems.

PRODUCTION AND TOXICITY OF SUBSTANCES MONITORED

Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless, tasteless, non-irritating gas that is produced when incomplete combustion of a carbonaceous material occurs.[14] Carbon monoxide is also a chemical asphyxiant which interferes with the oxygen-carrying capacity of the blood. Like oxygen (O_2) CO combines with hemoglobin, however, the affinity of hemoglobin for CO is 210 times that for O_2.[15] Since CO and O_2 combine with hemoglobin at the same point on the molecule and cannot both be bound to hemoglobin at the same time, CO precludes oxygen from binding to hemoglobin.

In addition, CO interferes with the release of O_2 to the tissues.[16] The result is tissue hypoxia. Factors such as heavy work, exercise, high temperatures, humidity with little or no air movement, and high altitude tend to increase respiration and heart rate, consequently resulting in more CO absorption. Other factors affecting CO absorption are concentration of CO, length of exposure, rate and depth of respiration, size and age of individual, smoking habits, emphysema, anemia, and coronary heart disease (CHD).[14]

The central nervous system and cardiovascular system are the most vunerable to CO.[17] Under resting conditions, the heart muscle (myocardium) extracts 75% of the available O_2 from the coronary arterial blood, leaving 25% of the O_2 for the coronary venous blood. Peripheral tissues, at rest, only need 25% of the O_2 available in the oxygenated arterial blood. The other 75% serves as a reserve supply. When the O_2 requirement of the peripherial tissues increases, the tissues extract more O_2 from the reserve supply in the blood circulating the tissues. However, when the myocardial tissue requires more O_2, it is unable to extract much from its small (25%) reserve supply. To compensate, the heart increases coronary blood flow (by dialation of the coronary arteries), heart rate, and blood pressure.[18] This additional stress in a person with preexisting cardiovascular disease can cause angina pectoris (chest pain), electrocardiographic (ECG) abnormalities, arrhythmia (irregular heart beat), or ischemia (insufficient supply of blood to the heart).

Evidence that supports this was work done by Stewart.[19] Human volunteers were exposed to CO at concentrations of less than one up to 1000 ppm for periods of ½ to 24 hours. No adverse effects were observed in these subjects at 100 ppm or less. However, as the exposure increased from 200 ppm to 1000 ppm, headaches, light headedness, hyperventilation, increased heart rate, nausea, changes in visual evoked response (VER), and impairment of manual coordination were reported.[19]

In another study, Aronow et. al.[20], exposed 10 patients (men between the ages of 40 and 56 years) with angina pectoris to exhaust fumes from 90 minutes of heavy los Angeles freeway traffic. They were exposed by riding in a station wagon with all the windows open. The patients' average COHb levels rose from 1.12% to 5.08%. Four subjects developed electrocardiographic abnormalities, and the average time to develop angina with treadmill exercise fell from 249.4 to 174.3 seconds. The test was repeated three weeks later, but the patients breathed compredded purified air. The average time to develop angina with treadmill exercise rose from 245.1 to 1249.9 seconds. Other studies have also shown that levels of COHb in excess of 5% can cause cardiovascular changes which are dangerous for persons with CHD.[21,22] Also, since a significant number of workers have CHD and many smoke, additional occupational exposure to CO may increase cardiovascular morbidity and mortality.[23]

Gorden J. Gilbert, M.D.[24] reported a case of chronic CO poisoning where there was low-grade but frequent exposure to CO. A critical level of CO was attained after only half a day's exposure at work. Thirty hours after the patient's last CO exposure, his blood level of COHb was 20%. The patient's symptoms and signs consisted of anorexia (loss of appetite), weight loss, and recurrent episodes of unconsciousness; each episode was preceded by a period of dizziness and ataxia (i.e., inability to coordinate voluntary muscular movements). After being removed from CO exposure, most symptoms and signs cleared in 2 weeks to 3 months. Others have cited examples of decrement in psychomotor performance (Schulte[25]) and changes in visual threshold in persons exposed to low levels of CO (Dinam[26]).

The Occupational Safety and Health Administration (OSHA) standard, permissible exposure limit (PEL), for CO is 50 ppm for an 8-hour Time Weighted Average (TWA)[27] and 1500 ppm for the Immediately Dangerous to Life and Health (IDLH) level.[28] The American Conference of Governmental Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 50 ppm for an 8-hour TWA and a Short Term Exposure Limit (STEL) of 400 ppm for 15 minutes.[29] The NIOSH recommended standards are 35 ppm for an 8-hour TWA and 200 ppm ceiling level (not to be exceeded)[2,28]. (See Appendix, Table A-3).

Nitrogen Dioxide (NO_2)

Oxides of nitrogen (NO_x) are contaminants commonly found in the work environment and atmosphere. They are produced by processes involving high temperatures such as the internal combustion engine and are emitted in vehicular exhaust. Most of the NO_x emitted from the internal combustion engine is in the form of nitric oxide (NO), an asphyxiant gas, which is oxidized in air to NO_2. Since the rate of oxidation depends on the square of the NO concentration, oxidation occurs more rapidly at higher NO concentrations.[30] For example:

200 ppm NO → 11 ppm NO_2/min
100 ppm NO → 2.8 ppm NO_2/min
25 ppm NO → 1 ppm NO_2/ 5 min

Moisture, metal fumes, and ultraviolet radiation may increase or decrease this rate of oxidation.

NO_2 is a mucous membrane irritant with an odor threshold of 0.5 ppm or less; however, olfactory fatigue develops rapidly.[30] Healthy adult males exposed to NO_2 at 4-5 ppm for 10-15 minutes were observed to have changes in airway resistance, arterial oxygen partial pressure, and alveolo-arterial pressure gradients.[31] Inhalation of NO_2 at levels of between 50-100 ppm causes irritant cough, mild or transient headache, and mild dyspnea. Acute pulmonary edema may develop after a characteristic delay of up to 12 hours if the exposure is severe (levels unknown). Death may follow.[30]

The OSHA PEL for NO_2 is 5 ppm[27,28] and 50 ppm for IDLH level.[28] NIOSH recommends a ceiling level of 1 ppm and ACGIH recommends a TLV of 3 ppm and a STEL of 5 ppm.[29] (See Appendix, Table A-3).

Polycyclic Aromatic Hydrocarbons (PAH's)

Polycyclic aromatic hydrocarbons are virtually ubiquitous, being found in air, water, soil, tissue, food, and tobacco smoke. More than 200 PAHs have been found in the environment, occurring primarily as products of combustion of organic matter. Many of these PAHs have been found experimentally to be mutagens and/or carcinogens.[32]

PAHs are components of gasoline, diesel fuel, and their resultant combustion; fuel with a higher PAH content produces vehicle exhaust with a higher PAH content. PAH production is favored by an O_2 deficient flame, temperatures of 650-900°C, and fuels which are not highly oxidized.[33] For example, Begeman[34] showed that the production of the PAH, benzo(a)pyrene (B(a)P), was 30 times greater when the air to fuel ratio was 10:1 as compared to 14:1 for automobiles. Emissions of B(a)P also increased with increased engine use, producing five times as much B(a)P after 50,000 miles of use than at 5,000 miles of use. Levels of B(a)P were ten times as high when autos obtained only 200 miles per quart of oil versus 1600 miles per quart of oil.

Sawicki et. al.,[35,36] showed that PAH levels are higher in city air than in rural air. B(a)P was present in all urban areas sampled; concentrations in 103 urban atmospheres ranged from 0.1 to 61 ng/m^3, with a geometric mean of 6.6 ng/m^3. B(a)P concentrations found in 28 rural areas ranged from 0.01 to 1.9 ng/m^3 with a mean of 0.4 ng/m^3.

For PAHs, the OSHA standard is listed as the benzene soluble fraction from either coke oven emissions or coal tar pitch volatiles. The OSHA coke oven emission standard is 0.15 mg/m^3[27] and the coal tar pitch volatiles standard (and ACGIH TLV[29]) is 0.2 mg/m^3 for 8-hour TWAs.[27,28] The OSHA IDLH level for coal tar pitch volatiles is 400 mg/m^3 and the NIOSH recommended standard for a 10-hour TWA is 0.1 mg/m^3.[28] In addition, NIOSH and ACGIH consider the benzene soluble fraction of coal tar pitch volatiles as carcinogenic.[28,29] (See Appendix, Table A-3).

Metals

Lead (Pb)

Inorganic lead (Pb) is ubiquitous in the environment and can be found in measurable amounts in all adult body tissues and fluids. Lead is also found in some gasoline in the organic (alkyl) forms as tetraethyl and tetramethyl lead. However, lead alkyl vapors are broken down by light and heat, therefore auto exhaust contains mostly inorganic Pb compounds. Approximately 80% of this inorganic Pb is emitted as particles <1 to <2 micrometers (um) in size; the remainder is deposited in the engine and exhaust system.[37]

Since most occupational exposure to Pb is by inhalation, particle size in important because particles <10 um can penetrate into the deeper regions of the lung.[38] Approximately 30-50% of inhaled Pb is absorbed and distributed throughout the body. Inhalation and ingestion of Pb may result in damage to the nervous, urinary, and reproductive systems and inhibit synthesis of heme, which is responsible for O_2 transport in the body.[39]

The blood lead (PbB) level is an indirect indicator of Pb exposure. Average PbB levels are <20 ug Pb/100 g of blood for 50% of the population and <35 ug Pb/100 g of blood for 98% of the population. Prevention of adverse health effects from exposure to Pb throughout a working lifetime requires that PbB levels be maintained at or below 40 ug Pb/100 g of blood.[39]

The OSHA standard for Pb is 0.05 mg/m^3 for an 8-hour TWA,[28] the NIOSH recommended standard is 0.1 mg/m^3 for an 8-hour TWA,[30] and the ACGIH TLV is 0.15 mg/m^3 for an 8-hour TWA and 0.45 mg/m^3 for a STEL.[29] (See Appendix, Table A-3).

Iron (Fe)

Iron is mainly used in the production of pig iron and steel. Much of the steel is used by the automotive industry in manufacturing of various types of vehicles. Due to the wear and tear and rusting of those vehicles, iron particles or iron oxide may be found in road dirt.

Iron oxide exposures over 6-10 years in industry may cause "iron pigmentation" or benign pneumoconiosis, termed siderosis. Symptoms and signs are few; however, moderate lung changes may be detected in chest x-rays.[40]

The OSHA standard for iron oxide (fume) is 10 mg/m^3 [28]; the ACGIH TLV and STEL levels are 5 mg/m^3 and 10 mg/m^3, respectively.[28,29] (See Appendix, Table A-3.)

Aluminum (Al)

In recent years, aluminum has been used in increasing amounts in the automotive industry to reduce the weight of vehicles. Aluminum (Al) is also used in highway signs, signal supports, and paint. Wear of these items could release small amounts of Al dust to the environment.

The soluble forms of Al are acutely toxic; however, the insoluble forms produce no detectable acute response. Chronic exposures to airborne metallic Al dust may cause dyspnea, cough, pneumothorax, variable sputum production, and possibly death.[41]

The ACGIH TLV and STEL levels for aluminum metal and oxide are 10 mg/m^3 and 20 mg/m^3, respectively.[29] (See Appendix, Table A-3).

Asbestos

Asbestos is used in the manufacture of automobile brake linings; through use and wear of the brakes, a small amount of asbestos may be released to the environment. Exposure to asbestos fibers can cause lung and gastrointestinal cancer and asbestosis in man. Lung cancers and asbestosis have occurred following exposure to the following forms of asbestos: chrysotile, crocidolite, amosite and anthophyllite. Fibers less than 0.5 um in diameter and greater than 5 um in length are most likely to produce tumors.[42] Although the risk of developing cancer is decreased by lowering the exposure level to asbestos, no "safe" level of asbestos exposure has been determined.[42]

The current OSHA standard for asbestos is 2 fibers, longer than 5 um, per cubic centimeter (cc) of air for an 8-hour TWA.[27] The OSHA ceiling concentration is 10 fibers, longer than 5 um, per cc of air.[27] The NIOSH recommended standard is 0.1 fibers, longer than 5 um, per cc of air for an 8-hour TWA with peak concentrations, based on a 15 minute sampling period, not exceeding 0.5 fibers, longer than 5 um, per cc of air.[43] ACGIH lists several asbestos TLVs as follows:[29]

Types of Asbestos	TLV
Amosite	0.5 fiber> 5 um/cc
Chrysotile	2 fibers> 5 um/cc
Crocidolite	0.2 fibers> 5 um/cc
Other Forms	2 fibers> 5 um/cc

(See Appendix, Table A-3).

SURVEY METHODS

General

Area and personal air samples were collected for bridge and tunnel officers at the QMT and TB, Manhattan Plaza. Area sampling only was conducted at the Bronx Plaza, TB. Sampling was conducted during 11 morning shifts, 12 afternoon shifts and 4 night shifts on 101 officers (see Appendix, Table A-4).

Substances sampled for include: carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAHs), nitrogen dioxide (NO_2), heavy metals (e.g., lead), and asbestos. Environmental conditions, e.g., temperature and humidity levels, were recorded and may be found in the Appendix, Tables A-5 and A-6. CO breath analysis was conducted on most officers who participated in personal CO sampling, and length of time employed and smoking history were recorded. (The list of all sampling equipment used during the survey may be found in Appendix, Table A-7).

Carbon Monoxide (CO)

Area samples were obtained using portable direct-reading CO monitors, Ecolyzer, Model #2100, manufactured by Energetics Science, Incorporated. Continuous strip-chart recorders were connected to the Ecolyzers for recording data storage of the CO measurements.

The Ecolyzers were calibrated daily and were used on either the 0-100 ppm or 0-600 ppm scale. Ecolyzers are normally accurate within 1 ppm on the 0-100 ppm scale and 6 ppm on the 0-600 scale. Samples were collected for 8-24 hours depending on the number of continuous shifts that were sampled. The locations sampled were: toll lanes, toll booths, top of the plaza canopy, tunnel catwalks, and tunnel observation booths.

Area and personal CO samples were obtained using Draeger direct-reading, long-duration detector tubes in line with MDA Accuhaler (Model 808) low-flow pumps (20 cc/min limiting orifice). Draeger tubes contain silica gel impregnated with chemicals that react with CO causing a color change or stain in the tube; the length of stain is proportional to the CO concentration.

Samples were collected for a period of 6-8 hours per shift. Length of stain and time sampled were recorded at the end of each sampling period. Although both Draeger tubes and Ecolyzers were used to collect area CO, they were not always used at comparable times and locations.

Breath Analysis

A pre-shift and post-shift breath analysis was performed on most of the officers who wore personal CO monitors. The test procedure involved:

1) exhaling completely
2) inhaling rapidly until lungs were filled
3) holding of breath for 20 seconds*
4) exhaling a small amount of breath into the ambient air
5) exhaling the remainder of the breath into a tube leading to a 5-liter Mylar sample bag.[44]

The Mylar bag was then attached to an Ecolyzer and the concentration of CO in the exhaled breath recorded. The percentage of carboxyhemoglobin in the blood was then estimated by using the method developed by Ringold, et. al.,[45] i.e., $COHb\% = 0.5 + \frac{CO \text{ in ppm}}{5}$. Other methods have been published[46] or recommended however, the Ringold method was used because it was based on experimental data.

Polycyclic Aromatic Hydrocarbons (PAHs)

Personal and area samples were collected at 1.9 Lpm for 6-8 hours per shift using Dupont P-4000 pumps. The PAH sampling train consisted of a glass fiber filter backed up with a silver membrane filter and a coarse polymer XAD2 tube. The

*Studies by Jones[44] have shown that maximal levels of alveolar partial pressure of CO (pCO) are attained within 20 seconds of breathholding, the test is easily reproduced, and the relation of alveolar pCO corresponding to blood COHb saturation was similar for all subjects tested.

filter collected the particulate fraction and the XAD2 tube trapped the PAH vapor fraction. The tubes were refrigerated after sampling, during storage and shipment. All samples were analyzed for the following PAHs: benzo(a)pyrene, chrysene, pyrene, fluoranthene, and benz(a)anthracene.

The cyclohexane soluble method was used to determine the concentration of PAHs in the samples collected at the Queens Midtown Tunnel. The benzene soluble method was inadvertently used to determine the concentration of PAHs in the samples collected at the Triborough Bridge. Both methods are essentially the same except that benzene will extract a wider range of substances such as aromatic hydrocarbons. Therefore, the benzene extraction will produce an increase in sample weight of total solubles as was observed in the sample results.

The individual PAHs were separated by reverse phase high performance liquid chromatography utilizing a Waters Associates HPLC system and ultraviolet (UV) absorption detector. Retention times of specific peaks in the chromatograms derived from the samples were compared with those of known standard compounds for analyte identification. The cyclohexane and benzene solubles of the filter samples were analyzed following a modification of NIOSH Method No. P&CAM 217.[47]

Nitrogen Dioxide (NO_2)

Personal and area sampling was conducted using Palmes tubes, passive monitors, which collect nitrogen dioxide (NO_2) by molecular diffusion (Brownian motion). Nitrogen dioxide diffuses through the tube and is absorbed in the triethanolamine (TEA) coating placed on a stainless steel grid (13/32 inch in diameter)[48].

The samples were analyzed for NO_2 by a modification of NIOSH Method P&CAM 231.[48,49] Volumes were scaled to 2.1 mL total reaction volume. The sulfanilamide and NEDA [N-(1-napthyl) ethylenediamine dihydrochloride] reagents were combined before adding to the filters, and no peroxide was used. Samples were analyzed by microanalysis on a Zeiss spectrophotometer.

Metals

Personal and area samples were collected on 0.8 micron AA Millipore filters inline with MSA Model G pumps. The flow rate was 1.5 Lpm with a collection time of 6-8 hours per shift.

A metal scan was run on five representative area samples to determine the amount and type of trace metals. This was done by ashing the samples with nitric acid and disolving the residues in dilute nitric-perchloric acid. The resulting solutions were analyzed for trace metal content by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES). The three metals chosen for further quantitative sample analysis were lead (Pb), aluminum (Al), and iron (Fe).

Analysis of these three metals was performed using NIOSH Method No. P&CAM 173.[50] The sample filters were wet ashed with nitric and perchloric acids to insure their complete oxidation, and the ashed samples were diluted to a final volume of 25 mL. The resulting solutions were analyzed by atomic absorption (AA) spectrophotometry.

Asbestos

Although asbestos was not listed in the protocol, interest was expressed in this substance during the survey. Therefore, four AA Millipore filters were used to collect asbestos fibers. The sampling train and method were the same as that for metals.

The filter asbestos counts were conducted using NIOSH Method No. P&CAM 239.[51] The filters were transformed from an opaque solid membrane to a transparent optically homogenous gel. The fibers were counted using a phase-contrast microscope at 400-450x magnification.

STATISTICAL METHODS

Various statistical analyses were conducted on CO and COHb data. The distributions of the area CO, personal CO, pre-shift COHb and post-shift COHb data were explored and it was found that: 1) Ecolyzer area CO data were lognormal while Draeger area CO data were normal and the combined (Draeger and Ecolyzer) area CO data were nearer to lognormal than to normal; 2) personal CO data were lognormal; and 3) pre and post-shift COHb data were nearer to lognormal than to normal.

Summary statistics such as the arithmetic mean, standard deviation,, geometric mean, geometric standard deviation and the 95% confidence limits of geometric means were calculated by different groupings for area CO, personal CO, and COHb, respectively. The difference between post-shift and pre-shift COHb was calculated for each pair of observations; the mean and standard deviation of the differences were then calculated.

Due to the lognormal (or nearer to lognormal than normal) distribution of the data, natural log transformed data were used in the hypothesis testings for group differences and correlation between variables.

RESULTS, OBSERVATIONS, AND DISCUSSIONS

The 8-hour TWA personal samples obtained at the QMT and TB indicated that the BTOs working inside the catwalk booths and/or the toll plaza booths had no appreciable exposure to CO, NO_2, PAHs, or metals. All 8-hour TWA area CO sample results collected in booths and most 8-hour TWA personal CO sample results were below the OSHA standard (50 ppm). However, one personal sample (tunnel worker-47 ppm) and several area 8-hour TWA CO samples were above the NIOSH (35 ppm) and/or OSHA standard (50 ppm). Five of the area samples (ranging from 42-73 ppm) were obtained in the TB toll lanes, and the remaining three (ranging from 39-81 ppm) were obtained on the QMT catwalks. (See Tables 9-12.)

Several catwalk CO readings (averaged hourly) were also above the OSHA standard (125-146 ppm with peaks to 375 ppm) even though most of the available exhaust and blower fans were running at high (2nd and 3rd) speeds. BTOs are only exposed to these levels during changing of tunnel posts and during traffic emergencies (approximately 5-15 minutes per exposure). However, BTOs who patrol lanes and direct traffic were exposed, at various times, to hourly averages of up to 89 ppm (peaks to 425 ppm) at QMT and 94 ppm (peaks to 442 ppm) at TB. (For CO TWA

Table 9

Average CO Personal Sampling Data (ppm)
Collected at QMT, TBTA
August 3-7, 1981

Date	Shift	Arithmetic Average Concentration (ppm) TWA
8/3/81	Afternoon	5.20
8/4/81	Morning	5.70
8/5/81	Afternoon	4.80
8/5/81	Afternoon	9.59
8/5/81	Night	5.97
8/6/81	Night	4.04
8/7/81	Morning	15.09
8/7/81	Afternoon	11.28

Table 10

Average CO Personal Sampling Data (ppm)
Collected at TB
August 10-13, 1981

Date	Shift	Arithmetic Average Concentration (ppm) TWA
8/10/81	Morning	7.39
8/10/81	Afternoon	5.95
8/11/81	Afternoon	6.54
8/11-12/81	Night	4.53
8/12-13/81	Night	3.58
8/13/81	Morning	6.39

Table 11

CO TWA Area Samples Collected at QMT
August 3-7, 1981

Date	Shift	Location	TWA (ppm)	Range (ppm)
8/3/81	Afternoon	Lane 5	23.4	10-86
		Lane 7	28.1	6-87
8/4/81	Morning	Lane 3	80.8	35-255
		Lane 7	43.5	0-355
		Above canopy	10.0	6-24
8/5/81	Morning	Lane 7	24.0	1-120
		Booth 7	9.4	3-26
		Catwalk (N-4)	47.4*	17->100*
	Afternoon	Catwalk (S-1)	123.8*	20-300*
		Booth 7	9.9	7-21
8/5-6/81	Night	Booth 7	7.4	6-14
8/6-7/81	Night	Lane 5	26.6	0-270
		Booth 7	6.4	6-8
8/7/81	Morning	Lane 5	28.6	2-248
		Booth 7	11.4	7-23
	Afternoon	Lane 7	39.3	20-120

* Tunnel computer shut down for maintenance

Table 12

CO TWA Area Samples Collected
at TB August 10-13, 1981

Date	Shift	Location	TWA (ppm)	Range (ppm)
8/10/81	Morning	Lane 10	72.8	30-258
	Afternoon		55.6	32-155
	Morning	Booth 10	23.1	10-51
	Afternoon		15.6	7-40
8/11/81	Afternoon	Lane 5	53.7	30-120
		Top of canopy	3.5	2-6
8/11-12/81	Night	Lane 5	52.9	30-165
		Booth 5	8.9	6-49
8/12-13/81	Night	Lane 12	31.4	0-167
		Booth 12	7.0	4-13
8/13/81	Morning	Lane 12	42.3	4-305

and peak values, see the Appendix, Tables A-8 through A-13). BTOs may be exposed to these levels for an hour or longer. BTOs working in the toll booths may also be exposed to these levels for short periods of time. This usually occurs in the summer when higher midday temperatures prompt some of the BTOs to open the rear sliding door of the toll booths, and when many of the BTOs lean out of the toll booths while collecting tolls.

The COHb results for the BTOs at the QMT and TB may be seen in Tables 13 and 14 and the Appendix, Tables A-14 and A-15. Although most nonsmokers post-shift COHb levels were higher than the pre-shift COHb levels, only one nonsmoker (QMT) had a post-shift COHb level (two had pre-shift levels) greater than 5%. On the other hand, many smokers (67%) had pre-shift as well as post-shift (70%) COHb values greater than 5%; however, smokers post-shift COHb levels usually remained about the same or decreased slightly. One incidence of a dramatic drop in COHb level was observed when one TB employee abstained from smoking for a 24-hour period; the officer's post-shift COHb level dropped from 8.9% to 2.4%. However, other BTOs smoked on duty, during breaks, and immediately before conducting the breath analysis test which caused their COHb level to remain high.

NIOSH has recommended that a nonsmoking employee's level of COHb not exceed 5% over an 8-hour workday. The NIOSH recommended standard of 35 ppm for CO was based on the 5% COHb level (which was based on cardiovascular and behavioral studies[2]); 5% is the amount of COHb that an employee (engaged in sedentary activity) would achieve in an 8-hour workday of continuous (35 ppm CO) exposure. The NIOSH recommended standard does not take smoking habits into consideration because (cigarette) smokers' COHb levels usually range from 4-5% prior to occupational exposure to CO.[2]

Results from the various statistical analyses which were conducted on the CO and COHb data are as follows. Hypothesis testing was conducted to determine the differences between QMT and TB, between QMT toll plaza and tunnel interior, and between smokers and nonsmokers for area CO, personal CO and COHb. (See Appendix, Tables A-16 through A-20.) Analysis of variance (ANOVA)[52] was chosen to test these hypotheses. Location and equipment and their interaction were sources of variation in the ANOVA of area CO. Location (either QMT vs TB, or QMT toll plaza vs tunnel interior), smoking history (current smokers vs exsmokers and nonsmokers combined), and their interaction were considered as sources of variation in the ANOVA of personal CO and COHb.

At the significance level of 0.05 or less the ANOVA results indicated: location differences (either QMT vs TB or QMT toll plaza vs tunnel interior) were significant for personal CO and pre-shift COHb; smoking habit differences were significant for pre- and post-shift COHb; and the effect of location and smoking habit interaction was not significant for personal CO, or pre- and post-shift COHb. For area CO, neither location (QMT vs TB or toll plaza vs tunnel interior) nor equipment (Draeger tubes vs Ecolyzers) differences were significant. (See Appendix, Tables A-21 through A-23.)

Table 13

Personal CO and COHb Data
Smokers vs Nonsmokers
QMT August 3-7, 1981

Date	Shift	Smoking History	Preshift COHb (%)	Postshift COHb (%)	Arithmetic Average CO Level (ppm) TWA
8/3/81	Afternoon	Nonsmokers	1.95	2.38	5.10
		Smokers	6.25	6.25	28.77
8/4/81	Morning	Nonsmokers	1.97	2.39	6.67
		Smokers	4.83	5.05	4.30
8/5/81	Morning	Nonsmokers	1.85	2.54	5.27
		Smokers	3.80	3.63	3.40
	Afternoon	Nonsmokers	1.98	2.38	5.53
		Smokers	4.22	4.42	15.68
	Night	Nonsmokers	2.00	1.63	5.97
		Smokers	8.50	8.60	-
8/6/81	Night	Nonsmokers	1.98	2.00	3.78
		Smokers	8.10	8.50	5.10
8/7/81	Morning	Nonsmokers	1.55	2.64	11.33
		Smokers	4.86	6.80	19.40
	Afternoon	Nonsmokers	2.20	2.95	13.74
		Smokers	6.91	9.09	8.21

Table 14

Personal CO and COHb Data
Smokers vs Nonsmokers
TB August 10-13, 1981

Date	Shift	Smoking History	Preshift COHb (%)	Postshift COHb (%)	Arithmetic Average CO Level (ppm) TWA
8/10/81	Morning	Nonsmokers	1.85	2.25	6.23
		Smokers	7.30	7.76	8.05
	Afternoon	Nonsmokers	1.82	2.50	5.85
		Smokers	7.30	8.30	6.25
8/11/81	Afternoon	Nonsmokers	2.40	2.37	6.99
		Smokers	6.73	7.83	4.75
8/11-12/81	Night	Nonsmokers	1.85	2.25	3.75
		Smokers	7.60	9.25	5.30
8/12-13/81	Night	Nonsmokers	1.90	2.00	4.00
		Smokers	5.30	5.25	3.15
8/13/81	Morning	Nonsmokers	1.88	2.32	6.44
		Smokers	6.50	6.30	6.33

The Pearson's correlation coefficient (r)[53] was calculated to determine whether there was a linear correlation between any of the variables: area CO, personal CO, pre-shift COHb, and post-shift COHb, and to determine the degree of correlation between them. A value of a positive or negative 1 shows a perfect correlation; a value of zero shows there is no correlation. Values of 0 to 0.4, 0.4 to 0.8, and 0.8 to 1 show, respectively, weak, moderate, and strong correlations. Number of observations and probability of significant difference were also noted. Results may be found in Appendix: Tables A-24 and A-25 and Figures A-1 through A-7. No correlation was seen between personal and area CO or between personal CO and pre-shift COHb. The correlation coefficient between personal CO and post-shift COHb ($r = 0.25$) was significantly different from zero as was the correlation coefficent between personal CO and change in post-shift and pre-shift COHb ($r = 0.29$). In order to determine if personal CO was actually correlated to the change in post-shift and pre-shift COHb levels, a partial correlation analysis was conducted holding location and smoking factors constant. The result was a partial correlation of 0.30 and a probability of 0.01 which indicates that approximately 9% of the change in post-shift and pre-shift COHb levels is explained by personal CO concentrations.

There are several factors which may confound correlations between CO exposures and health effects of BTOs. First BTOs may be exposed to CO in their off-duty hours, e.g., while driving to and from work, smoking, or being in the presence of other smokers, especially in a confined area (small room or automobile). Second, BTOs are exposed to other toxic substances while working during off-duty hours and while smoking or being in the presence of those who are smoking. Therefore, it may be difficult to pinpoint which substance or combination of substances are causing a certain health effect. Third, CO levels vary considerably from minute to minute and from day to day. Although the BTOs are usually exposed to low levels of CO, they may be exposed to CO levels above the NIOSH recommended ceiling level for short periods of time (while on the tunnel catwalk, directing traffic and patrolling lanes) during rush hour traffic. The 200 ppm ceiling level was recommended to prevent adverse health effects from peak CO exposures, therefore, higher peak exposures may make it more difficult to determine if an excess in mortality was due only to low CO concentrations. Fourth, relating area and personal sampling data is difficult since BTOs may have been in several different locations through a shift and it was not possible to conduct area sampling at all work locations.

For NO_2, all 8-hour TWA personal and area sampling results obtained at the TB were within 11-15% of the NIOSH recommended ceiling level of 1 ppm. (See Appendix, Tables A-26 through A-28.) At the QMT, all but one personal (1.66 ppm) and one area (1.36 ppm) 8-hour TWA sampling results fell within 12-83% of the NIOSH recommended ceiling level of 1 ppm.

Most personal and area PAH samples collected at the TB and QMT were at or below the analytical limit of detection. All benzene soluble fractions from PAH samples collected at the TB were below the OSHA and NIOSH standards. However, four of the cyclohexane soluble fractions taken from PAH area samples collected at the QMT were above the NIOSH recommended standard of 0.1 mg/m^3, and one from a QMT personal PAH sample was above the OSHA (benzene soluble fraction) standard of 0.2 mg/m^3 (see the Appendix, Tables A-29 through A-31).

All QMT and TB personal and QMT area TWA metal sample results were below the NIOSH recommended and OSHA standards. One TB area sample for lead (0.13 mg/m^3) was above the NIOSH and OSHA standards of 0.1 and 0.05 mg/m^3, respectively. (See the Appendix, Tables A-32 and A-33.) All asbestos area sample results were well below the OSHA standard (2 fibers/cc) and the NIOSH recommended standard (0.1 fiber/cc). (See the Appendix, Table A-34.)

Review of the previous noise study conducted at TBTA,[13] and exposure to tunnel catwalk conditions (having to shout to be heard at distances of 6 inches to 1 foot) indicated that the tunnel catwalk noise levels were above 90 dBA.[54] Although the tunnel catwalk levels are consistently above 90 dBA, the BTOs are only exposed to these levels during changing of tunnel posts and during traffic emergencies (approximately 5-15 minutes per exposure).

A potential for stress was revealed in discussions with BTOs and in observations of BTOs' reactions to certain situations. Some potentially stressful situations encountered by BTOs are: dealing with persons who are aggravated by waiting to pay tolls or being involved in traffic accidents, issuing traffic tickets, making arrests (while being uniformed similarly to the NYC police but not being armed), or working swing shifts and considerable amounts of overtime. Observed reactions to these situations included raising of the voice and general irritability. Other alledged reactions or personal experiences verbalized by several BTOs included sleeping and eating irregularities, fatigue, and family problems. Regarding these reactions to various work situations, it has been documented that 1) stress may cause fatigue (which can lead to depression)[55] and 2) shift work causes sleep deprivation[56] which may also cause fatigue. (Noise can also cause fatigue, nervousness, irritability, hypertension, and add to the overall stress of living).[54]

CONCLUSIONS

Worker exposure to CO, NO_2, PAHs, heavy metals and asbestos was assessed at the TBTA. The BTOs' exposure to NO_2, PAHs, heavy metals, and asbestos did not constitute a health hazard that was likely to be manifested since these levels were generally below the NIOSH recommended and/or OSHA standards.

During rush hours, tunnel traffic increased to the extent that vehicles were queued inside and outside of the tunnel. Since idling vehicles exhaust more CO than moving vehicles, the levels of CO increased during rush hours. Therefore, levels of CO are higher in the toll lanes than in the toll booths; and if the BTOs lean out of the booths to collect tolls they may increase their CO exposure. Opening of the sliding rear booth door (to attempt to cool the booth interior during the summer) may also increase BTOs' exposure to CO since the effect of the forced air ventilation is negated.

Regulation of tunnel ventilation is usually conducted by computer and is no longer a regular part of the BTOs' work routine. Therefore, tunnel (catwalk) CO levels sometimes are inadvertently allowed to increase to higher levels during manual operation. Thus the potential exists, especially during rush hours, for an appreciable exposure to CO when working inside the general tunnel atmosphere. The booth (CO peaks above 100 ppm at the TB) and tunnel ventilation systems were not always capable of handling auto exhaust during peak traffic periods; however, only one BTO had a personal CO exposure level above the NIOSH recommended standard.

Smoking increased the BTOs' exposure to CO which was shown by the smokers' pre-shift COHb levels. Sixty-seven percent of all smoking BTOs (only one nonsmoker) had pre-shift COHb levels greater than the NIOSH recommended standard of 5%. The pre-shift COHb mean of smokers was also higher than that of nonsmokers.

Since levels of COHb in excess of 5% can cause cardiovascular changes which are dangerous for persons with coronary heart disease (CHD), cardiovascular morbidity and mortality may be increased for those BTOs who have CHD and smoke when occupationally exposed to CO (e.g., higher levels of CO found in toll lanes).

Although most of the BTOs' occupational exposure to CO was below the current OSHA standard and NIOSH recommended standard, controversy still surrounds the effects of chronic exposure to low levels of CO on human subjects. Therefore, the safest level of CO exposure, as suggested by Torino,[57] is the lowest level which can reasonably be achieved.

Statistical analysis of the results indicates that the differences between locations (QMT and TB) and between smokers and nonsmokers were significant for personal CO. Also, examination of pre-shift and post-shift COHb levels, separately, showed there were significant differences between locations and smokers and nonsmokers. However, personal CO was found to be a better predictor of COHb change (between pre and post-shift) than smoking habits and location.

Tunnel catwalk noise levels were above the OSHA standard, however, most BTOs' 8-hour TWA exposure levels were less than 90 dBA. In addition, observations of and discussions with BTOs indicated that there is a potential for stressful situations which may be detrimental to their general well-being.

RECOMMENDATIONS

1. Periodically monitor area and personal CO levels, especially during summer months and rush hours (e.g., where BTOs patrol lanes and direct traffic).

2. Limit amount of time BTOs (including sergeants) patrol lanes and/or direct traffic to 60 minutes when CO levels reach 70 ppm, 50 minutes at 80 ppm, 40 minutes at 100 ppm, 30 minutes at 125 ppm, and less than 20 minutes at 200 ppm. (See the Appendix, Figures A-8 and A-9).

3. Educate BTOs on the health hazards involved (increasing their CO exposure) in leaning out of toll booths and keeping the rear door of toll booths open.

4. Investigate the feasibility of implementing a cooling system or overhead cool air wash to be used when booth temperatures and humidity levels are elevated.

5. Periodically conduct tunnel ventilation investigations to insure proper operation of the ventilation system.

6. More closely monitor tunnel ventilation control panel during computer downtime by assigning one BTO to monitor the control panel.

7. Implement a smoking cessation program and inform employees of potential hazards associated with additive effects of cigarette smoke and CO exposure.

8. Provide free access to hearing protection for BTOs who must enter the general tunnel area.

9. Improve the safety program by increasing safety training and awareness in order to reduce the total number of injuries.

10. Investigate the feasibility of conducting a health study on occupational stresses, especially with regard to shift rotation and overtime.

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APPENDIX

TABLE A-1

DAILY TRAFFIC VOLUMES - TB/MANHATTAN PLAZA 8/10-13/81

TIME	AUG. 10, 1981	AUG. 11, 1981	AUG. 12, 1981	AUG. 13, 1981
12 midnight- 1 am	1,735	1,276	1,607	1,541
1 am - 2 am	781	696	893	665
2 am - 3 am	405	423	541	415
3 am - 4 am	297	318	340	327
4 am - 5 am	294	340	400	358
5 am - 6 am	925	947	961	998
6 am - 7 am	3,159	3,114	3,136	3,235
7 am - 8 am	5,802	5,670	5,970	5,928
8 am - 9 am	5,732	5,988	6,206	6,294
9 am -10 am	4,732	4,676	4,262	5,144
10 am -11 am	4,675	4,241	4,587	4,696
11 am -12 noon	4,306	3,910	4,022	4,438
12 noon- 1 pm	3,760	3,808	4,020	4,274
1 pm - 2 pm	3,783	3,906	4,545	4,365
2 pm - 3 pm	4,280	4,386	4,794	5,036
3 pm - 4 pm	5,221	5,299	5,931	5,862
4 pm - 5 pm	5,445	5,847	6,524	6,268
5 pm - 6 pm	6,071	6,156	6,987	6,942
6 pm - 7 pm	5,248	5,205	6,779	6,479
7 pm - 8 pm	4,121	4,183	5,925	5,073
8 pm - 9 pm	3,326	3,275	3,961	3,914
9 pm -10 pm	2,783	2,757	3,064	3,354
10 pm -11 pm	2,506	2,690	2,935	2,806
11 pm -12 midnight	2,128	2,634	2,522	2,654
TOTALS	81,515	81,745	90,912	91,066

TABLE A-2

DAILY TRAFFIC VOLUMES - QMT 8/3-7/81

TIME	AUG. 3, 1981	AUG. 4, 1981	AUG. 5, 1981	AUG 6, 1981	AUG. 7,1981
12 midnight- 1 am	2,067	1,350	1,633	1,638	1,754
1 am - 2 am	881	740	860	874	1,059
2 am - 3 am	547	750	579	631	719
3 am - 4 am	406	429	460	543	574
4 am - 5 am	437	507	532	500	570
5 am - 6 am	943	922	989	975	978
6 am - 7 am	2,462	2,464	2,483	2,469	2,425
7 am - 8 am	4,614	4,746	4,650	4,449	4,189
8 am - 9 am	4,959	4,753	4,457	4,731	4,599
9 am -10 am	4,032	4,496	4,745	4,092	4,039
10 am -11 am	3,950	3,768	3,379	3,950	3,877
11 am -12 noon	3,738	3,487	3,347	3,633	3,820
12 noon- 1 pm	3,555	3,132	3,868	3,397	3,703
1 pm - 2 pm	3,391	3,252	3,218	3,355	3,505
2 pm - 3 pm	3,614	3,528	3,470	3,532	3,921
3 pm - 4 pm	4,106	4,244	4,006	3,961	4,295
4 pm - 5 pm	4,421	4,462	4,576	4.100	4,160
5 pm - 6 pm	4,445	5,059	4,959	4,709	4,286
6 pm - 7 pm	4,465	4,794	4,672	4,609	4,365
7 pm - 8 pm	3,402	4,182	4,159	3,865	3,909
8 pm - 9 pm	2,907	3,182	3,259	2,985	3,275
9 pm -10 pm	2,668	3,082	2,695	2,745	2,694
10 pm-11 pm	2,555	3,205	3,165	2,893	3,010
11 pm-12 midnight	2,275	2,813	2,562	2,703	2,924
TOTALS	70,840	73,248	72,723	71,344	72,650

TABLE A-3

Applicable Standards
of Substances Sampled at TBTA
8/3-13/81

Substance Monitored	OSHA Standard		NIOSH Recommended Standard		ACGIH Recommended Standard	
	PEL	IDHL	TWA	Ceiling	TLV	STEL
CO	50 ppm	1500 ppm	35 ppm	200 ppm	50 ppm	400 ppm
NO_2	5 ppm	50 ppm		1 ppm	3 ppm	5 ppm
PAH's (coal tar pitch volatiles)	0.2 mg/m^3	400 mg/g^3	0.1 mg/m^3		0.2 mg/m^3	
(Coke Oven Emissions)	0.15 mg/m^3					
Pb	0.05 mg/m^3		<0.1 mg/m^3		0.15 mg/m^3	0.45 mg/m^3
Fe (dust)	10 mg/m^3				5 mg/m^3	10 mg/m^3
Al (metal)					10 mg/m^3	20 mg/m^3
Asbestos, >5um in length	2 fibers/ cc	10 fibers/ cc	0.1 fiber/ cc	0.5 fiber/ cc	0.2 to 2 fibers/cc depending on type	

Table A-4

Shifts Sampled During CO
Survey at QMT and TB

Location	Date	Shift
QMT	8/3/81 (Mon)	3 pm - 11 pm
		4 pm - Midnight
	8/4/81 (Tue)	6 am - 2 pm
		7 am - 3 pm
		8 am - 4 pm
	8/5/81 (Wed)	7 am - 3 pm
		8 am - 4 pm
		3 pm - 11 pm
		4 pm - Midnight
	8/5-6/81 (Wed, Thur)	11 pm - 7 am
	8/6-7/81 (Thur, Fri)	11 pm - 7 am
	8/7/81 (Fri)	6 am - 2 pm
		7 am - 3 pm
		8 am - 4 pm
		3 pm - 11 pm
		4 pm - Midnight
TB	8/10/81 (Mon)	6 am - 2 pm
		7 am - 3 pm
		2 pm - 10 pm
		3 pm - 11 pm
	8/11/81 (Tue)	2 pm - 10 pm
		3 pm - 11 pm
		4 pm - Midnight
	8/11-12/81 (Tue, Wed)	5 pm - 1 am
		11 pm - 7 am
	8/12-13/81 (Wed, Thur)	11 pm - 7 am
	8/13/81 (Thur)	7 am - 3 pm

TABLE A-5

ENVIRONMENTAL CONDITIONS DURING SURVEY OF QUEENS MIDTOWN TUNNEL* 8/3-7/81

ATE	TIME (E.S.T.)	TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (MPH)	WIND DIRECTION	GENERAL WEATHER CONDITIONS
-3-81	3 p.m.	80	67	12	SSE	CLOUDY
	4 p.m	80	67	10	SSE	PARTLY SUNNY
	5 p.m.	78	69	14	SE	SUNNY
	6 p.m.	77	71	9	SW	PARTLY CLOUDY
	7 p.m.	77	69	8	S	PARTLY CLOUDY
	8 p.m.	77	74	7	S	PARTLY CLOUDY
	9 p.m.	75	82	12	S	PARTLY CLOUDY
	10 p.m.	75	82	11	SW	PARTLY CLOUDY
	11 p.m.	75	85	5	S	PARTLY CLOUDY
-4-81	7 a.m.	75	82	6	W	SUNNY
	8 a.m.	79	72	CALM	CALM	SUNNY
	9 a.m.	82	65	5	WNW	SUNNY
	10 a.m.	85	63	5	WNW	SUNNY
	11 a.m.	84	61	6	WSW	SUNNY
	12 noon	88	54	CALM	CALM	PARTLY SUNNY
	1 p.m.	88	57	5	WSW	PARTLY SUNNY
	2 p.m.	91	52	8	W	PARTLY SUNNY
	3 p.m.	88	52	12	W	PARTLY SUNNY
5-81	7 a.m.	76	85	10	WSW	PARTLY SUNNY
	8 a.m.	80	79	7	WSW	PARTLY SUNNY
	9 a.m.	85	70	7	NW	PARTLY SUNNY
	10 a.m.	87	63	10	WNW	PARTLY SUNNY
	11 a.m.	87	55	9	W	THUNDERSTORM/CL.
	12 noon	88	55	12	WNW	MOSTLY CLOUDY
	1 p.m.	90	44	13	NW	PARTLY SUNNY
	2 p.m.	88	47	14	WNW	PARTLY SUNNY
	3 p.m.	86	50	14	WNW	SUNNY
	4 p.m.	85	48	16	WNW	PARTLY SUNNY
	5 p.m.	83	51	13	NW	SUNNY
	6 p.m.	81	53	12	NW	SUNNY
	7 p.m.	79	56	16	NW	CLEAR
	8 p.m.	77	60	13	NNW	CLEAR
	9 p.m.	75	64	16	NW	PARTLY CLEAR
	10 p.m.	75	64	15	NW	CLEAR
	11 p.m.	74	69	12	NW	CLEAR
	12 midnight	73	69	12	NW	CLEAR

TABLE A-5 (cont.)

ENVIRONMENTAL CONDITIONS DURING SURVEY OF QUEENS MIDTOWN TUNNEL* 8/3-7/81

ATE	TIME (E.S.T.)	TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (MPH)	WIND DIRECTION	GENERAL WEATHER CONDITIONS
-6-81	1 a.m.	72	69	15	NW	CLEAR
	2 a.m.	72	69	10	NW	CLEAR
	3 a.m.	71	69	10	NW	CLEAR
	4 a.m.	70	71	8	NW	CLEAR
	5 a.m.	69	73	11	NW	SUNNY
	6 a.m.	70	70	7	NW	SUNNY
	7 a.m.	73	66	6	WSW	SUNNY
	11 p.m.	75	62	9	NW	PARTLY CLOUDY
	12 midnight	75	64	8	NW	PARTLY CLOUDY
3-7-81	1 a.m.	74	66	11	NW	PARTLY CLOUDY
	2 a.m.	72	71	7	N	PARTLY CLOUDY
	3 a.m.	70	79	8	N	PARTLY CLOUDY
	4 a.m.	70	71	11	N	CLOUDY
	5 a.m.	69	76	7	N	SUNNY
	6 a.m.	70	66	10	NE	SUNNY
	7 a.m.	72	64	9	NNE	SUNNY
	8 a.m.	75	60	5	NNE	SUNNY
	9 a.m.	78	60	6	NE	SUNNY
	10 a.m.	80	56	5	N	SUNNY
	11 a.m.	81	55	6	NNW	MOSTLY SUNNY
	12 noon	85	48	5	NNW	SUNNY
	1 p.m.	86	46	CALM	CALM	SUNNY
	2 p.m.	85	48	4	S	PARTLY SUNNY
	3 p.m.	85	50	7	SSW	PARTLY SUNNY
	4 p.m.	82	53	12	S	PARTLY SUNNY
	5 p.m.	78	58	13	SSE	SUNNY
	6 p.m.	76	60	6	S	SUNNY
	7 p.m.	75	64	9	S	CLEAR
	8 p.m.	75	62	5	SSE	PARTLY CLOUDY
	9 p.m.	75	62	7	S	PARTLY CLOUDY
	10 p.m.	75	64	6	SE	PARTLY CLOUDY
	11 p.m.	75	64	7	SE	PARTLY CLOUDY

* Due to wind damage to NIOSH weather equipment, environmental data was requested from the National Weather Service, Department of Commerce, New York, New York. Comparison of temperature data showed little difference in day time recordings, however, NIOSH night time recordings were consistantly higher by 1-7°F.

TABLE A-6

ENVIRONMENTAL CONDITIONS DURING SURVEY
OF TRIBOROUGH BRIDGE

ATE	TIME (E.S.T.)	TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (MPH)	WIND DIRECTION	GENERAL WEATHER CONDITIONS
-10-81	7 a.m.	78	69	CALM	CALM	SUNNY
	8 a.m.	82	59	8	NW	SUNNY
	9 a.m.	85	57	9	N	SUNNY
	10 a.m.	86	53	8	N	SUNNY
	11 a.m.	88	53	8	NW	SUNNY
	12 noon	90	49	10	S	MOSTLY SUNNY
	1 p.m.	92	43	11	N	SUNNY
	2 p.m.	92	41	12	N	SUNNY
	3 p.m.	90	42	12	NNW	SUNNY
	4 p.m.	89	44	9	NNE	SUNNY
	5 p.m.	86	50	11	SE	SUNNY
	6 p.m.	84	53	5	E	CLEAR
	7 p.m.	82	55	7	N	CLEAR
	8 p.m.	80	60	5	N	CLEAR
	9 p.m.	80	65	5	N	CLEAR
	10 p.m.	80	63	7	N	CLEAR
	11 p.m.	79	67	6	N	CLEAR
-11-81	3 p.m.	86	80	15	SE	RAINSHOWER
	4 p.m.	82	65	13	E	CLOUDY
	5 p.m.	81	72	13 w/gusts to 23	S	MOSTLY CLOUDY
	6 p.m.	79	79	13 "	S	PARTLY CLOUDY
	7 p.m.	79	88	9	S	MOSTLY CLOUDY
	8 p.m.	79	67	15 w/gusts to 27	SW	CLOUDY
	9 p.m.	75	79	11	SW	CLOUDY
	10 p.m.	75	74	6	SW	CLOUDY
	11 p.m.	74	74	5	W	PARTLY CLOUDY
	12 midnight	74	79	8	NW	CLOUDY
-12-81	1 a.m.	74	79	6	NW	PARTLY CLOUDY
	2 a.m.	74	79	5	WNW	PARTLY CLOUDY
	3 a.m.	72	87	4	NW	CLOUDY
	4 a.m.	73	85	6	NNE	CLOUDY
	5 a.m.	73	85	CALM	CALM	CLOUDY
	6 a.m.	74	81	6	ENE	CLOUDY
	7 a.m.	75	82	6	NE	CLOUDY
	11 p.m.	72	90	8	W	CLOUDY
	12 midnight	72	90	12	W	CLOUDY

TABLE A-6 (cont.)

ENVIRONMENTAL CONDITIONS DURING SURVEY OF TRIBOROUGH BRIDGE

DATE	TIME (E.S.T.)	TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (MPH)	WIND DIRECTION	GENERAL WEATHER CONDITIONS
8-13-81	1 a.m.	72	90	6	WSW	CLOUDY
	2 a.m.	72	84	5	NW	PARTLY CLOUDY
	3 a.m.	72	82	7	NNW	PARTLY CLOUDY
	4 a.m.	72	82	5	NW	CLOUDY
	5 a.m.	71	79	4	NW	CLOUDY
	6 a.m.	74	74	5	NW	PARTLY SUNNY
	7 a.m.	75	66	8	N	PARTLY SUNNY
	8 a.m.	77	64	5	NW	PARTLY SUNNY
	9 a.m.	80	60	5	N	PARTLY SUNNY
	10 a.m.	83	55	9	NW	PARTLY SUNNY
	11 a.m.	83	44	5	NW	CLOUDY
	12 noon	83	44	8	N	CLOUDY
	1 p.m.	85	42	10	NW	CLOUDY
	2 p.m.	84	45	9	NW	MOSTLY CLOUDY
	3 p.m.	81	51	10	W	CLOUDY

Due to wind damage to NIOSH weather eqqipment, environmental data was requested from the National Weather Service, Department of Commerce, New York, New York. Comparison of temperature data showed little difference in day time recordings, however, NIOSH night time recordings were consistantly higher by 1-7°F.

Table A-7

Sampling Equipment Used
at QMT and TB
August 3 - 13, 1981

Substance Sampled	Type of Monitoring	Sampling Equipment
Carbon Monoxide	Area and Breath Analysis	Ecolyzer (Model 2100) with strip chart recorder
Carbon Monoxide	Area and Personal	Draeger tubes with MDA Accuhaler pumps
Nitrogen Dioxide	Area and Personal	Palmes tubes
Polynuclear Aromatic Hydrocarbons	Area and Personal	Glass fiber filter Silver membrane filter Course polymer XAD2 tube Dupont P-4000 pump
Metals	Area and Personal	0.8 micron AA Millipore filter, MSA (Model G) pump
Asbestos	Area	Same as metals

The flow rate was 20 cc/min for CO (area and personal), passive diffusion for NO_2, 1.9 Lpm for PAHs, and 1.5 Lpm for metals.

TABLE A-8

CO TWA Results (ppm) for Area Samples Collected With Draeger Tubes at QMT [(a)]

Date	Shift	Pump Location	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO	CO Concentration
8-4-81	7:00am- 3:00pm	Lane 3	7:22am/ 3:10pm	23912.5/24448.4	6.24	95	28.0
8-5-81	7:00am- 3:00pm	Booth 7	8:16am/ 3:40pm	35157.5/37834.5	4.89	50	3.8
8-5-81	7:00am- 3:00pm	Tunnel N-4	9:02am/ 5:28pm	48541.7/48810.8	4.81	10	7.8
8-5-81	7:00am- 3:00pm	Catwalk N-4	9:10am/ 5:30pm	26114.7/27368.7	5.61	240	34.1
8-5-81	2:00pm-10:00pm	Catwalk S-1	2:15pm/10:10pm	43695.0/47120.1	5.96	500	29.4
8-5-81	2:00pm-10:00pm	Catwalk S-1	2:20pm/10:10pm	52072.9/53887.8	4.46	450	55.6
8-5-81	3:00pm-10:00pm	Tunnel Booth 10	3:40pm/10:10pm	25616.5/26622.0	6.24	20	3.2
8-5/6-81	7:00pm- 3:00am	Lane 13	7:05pm/ 3:05am	27402.8/28808.0	5.61	90	11.0
8-5/6-81	7:00pm- 1:00am	Booth 7	7:10pm/ 1:00am	37168.0/38294.0	5.71	20	3.1
8-5/6-81	7:00pm- 3:00am	Lane 8	7:00pm/ 3:00am	21968.8/23434.0	5.74	65	7.7
8-7-81	6:00am- 2:00pm	Catwalk N-4	6:15am/ 2:13pm	61436.0/63028.0	5.09	320	39.5
8-7-81	6:00am- 2:00pm	Tunnel Booth 47	6:05am/ 2:13pm	18826.0/20108.0	5.64	50	6.9
8-7-81	2:00pm- 9:00pm	Catwalk S-1	2:25pm/ 9:05pm	82169.0/82450.1	3.60	60	59.4
8-7-81	2:00pm- 9:00pm	Tunnel Booth 10	2:25pm/ 9:05pm	53702.0/54896.8	4.95	10	1.7
8-7-81	4:00pm-12:00am	Lane 10	4:20pm/ 7:50pm	29021.9/30131.9	6.31	100	31.3
8-7-81	4:00pm-12:00am	Lane 2	4:33pm/12:06am	78328.4/79920.3	5.01	230	28.8
8-7-81	4:00pm-12:00am	Lane 8	4:25pm/12:05am	63032.1/63948.1	5.09	100	21.5

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

TABLE A-9

CO TWA Results (ppm) for Area Samples Collected With Draeger Tubes at TB-M and TB-B Plazas (a)

Date	Shift	Pump Location	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO	CO Concentration
8-10-81	2:00pm-10:00pm	TB-B:Lane 10	1:25pm/ 9:25pm	16360.2/18512.0	4.64	270	27.1
8-10-81	2:00pm-10:00pm	TB-B:Lane 13	1:30pm/ 9:27pm	29060.5/30376.4	6.24	195	23.8
8-10-81	2:00pm-10:00pm	TB-B:Lane 15	1:36pm/ 9:27pm	79920.3/81404.2	5.01	170	22.9
8-10-81	2:00pm-10:00pm	TB-B:Lane 5	1:45pm/ 9:21pm	63948.2/65295.2	5.09	235	34.3
8-11/12-81	11:00pm- 7:00am	TB-M:Lanes 3&5	11:30pm/ 7:00am	65295.2/66273.2	5.09	45	9.0
8-12-81	12:00am- 8:00am	TB-M:Lane 12	12:10am/ 7:25am	31196.9/32208.9	6.31	200	31.3
8-12/13-81	11:00pm- 7:00am	TB-M:Lane 5	11:20pm/ 3:40am	37668.5/40538.5	5.80	280	16.9
8-12/13-81	11:00pm- 7:00am	TB-M:Lane 12	11:10pm/ 8:02am	26676.9/27333.9	5.74	120	31.8
8-13-81	8:00am- 4:00pm	TB-M:Lane 14	8:00am/ 3:35pm	53306.8/54139.7	4.81	150	37.4
8-13-81	8:00am- 4:00pm	TB-M:Lane 12	8:07am/ 3:25pm	30782.2/31237.1	6.08	30	11.0
8-13-81	8:00am- 4:00pm	TB-M:Lane 2	8:31am/ 3:43pm	22339.2/23722.2	3.91	65	12.0
8-13-81	9:00am- 5:00pm	TB-B:Lane 12	9:13am/ 5:00pm	23550.6/24785.2	3.84	115	24.3
8-13-81	9:00am- 5:00pm	TB-B:Lane 10	9:15am/ 5:03pm	18808.3/20657.4	4.14	220	28.7
8-13-81	9:00am- 5:00pm	TB-B:Lane 2	9:23am/ 5:10pm	87844.0/88965.0	3.60	50	12.0
8-13-81	9:00am- 5:00pm	TB-B:Lane 4	9:25am/ 5:05pm	35299.0/37206.0	4.25	175	21.6

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within $\pm$ 2% of actual values.

Table A-10

CO TWA Results (ppm) for Personal Samples Collected at QMT [(a)]

Date	Shift	ID Number	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO	CO Concentration
8-3-81	4:00pm-12:00am	C1-1A	3:35pm/11:47pm	71205.4/71923.4	5.01	20	5.6
8-3-81	4:00pm-12:00am	C2-1A	3:38pm/11:50pm	28287.9/28511.8	5.98	5	3.7
8-3-81	4:00pm-12:00am	C3-1	3:40pm/11:27pm	34136.6/34562.5	5.80	15	6.1
8-3-81	4:00pm-12:00am	C4-1A	3:43pm/11:57pm	17499.5/17984.5	3.84	5	2.7
8-3-81	4:00pm-12:00am	C6-1A	3:46pm/11:45pm	26275.8/26662.8	6.00	10	4.3
8-3-81	4:00pm-12:00am	C7-1A	3:49pm/11:53pm	89968.1/90699.2	4.14	5	1.7
8-3-81	4:00pm-12:00am	C8-1A	3:51pm/11:51pm	23004.4/23912.4	6.24	10	1.8
8-3-81	4:00pm-12:00am	C9-1A	3:54pm/12:01am	69888.1/70380.0	5.68	10	3.6
8-3-81	3:00pm-11:00pm	C10-1	3:57pm/10:49pm	49914.9/50053.7	4.95	10	14.6
8-3-81	3:00pm-11:00pm	C11-1A	4:09pm/11:07pm	27257.5/27995.7	4.48	20	6.0
8-3-81	3:00pm-11:00pm	C12-1A	4:10pm/10:39pm	86619.4/87349.3	3.79	20	7.2
8-4-81	7:00am- 3:00pm	C16-1A	6:42am/ 3:01pm	50053.7/50221.3	4.95	5	6.0
8-4-81	7:00am- 3:00pm	C17-1A	6:42am/ 3:06pm	72333.3/72854.2	5.01	20	7.7
8-4-81	7:00am- 3:00pm	C21-1	6:55am/ 3:10pm	28511.8/28734.7	5.98	5	3.8
8-4-81	8:00am- 4:00pm	C23-1	6:58am/ 3:06pm	18581.4/18754.4	5.64	0	0
8-4-81	8:00am- 4:00pm	C26-1A	7:40am/ 4:10pm	20928.2/21801.2	4.44	10	2.6
8-4-81	8:00am- 4:00pm	C27-1A	7:43am/ 3:09pm	27381.9/27847.9	6.31	25	8.5
8-5-81	7:00am- 3:00pm	C29-1A	6:40am/ 3:10pm	24448.5/25611.4	6.24	30	4.1
8-5-81	7:00am- 3:00pm	C30-1A	6:42am/ 2:55pm	28734.8/29889.8	5.98	45	6.5
8-5-81	7:00am- 3:00pm	C32-1A	6:47am/ 3:09pm	87359.3/87566.4	3.79	0	0
8-5-81	7:00am- 3:00pm	C17-1B	6:50am/ 1:39pm	72854.2/74572.4	5.01	45	5.2
8-5-81	7:00am- 3:00pm	C35-1	6:55am/ 3:06pm	12044.8/13840.2	4.14	25	3.4
8-5-81	3:00pm-11:00pm	C13-1A	2:41pm/10:58pm	18157.4/20018.0	3.84	45	6.3
8-5-81	3:00pm-11:00pm	C11-1B	2:44pm/11:12pm	70500.0/71864.0	5.68	70	9.0
8-5-81	3:00pm-11:00pm	C12-1B	2:46pm/10:50pm	34646.5/36227.0	6.09	35	3.6

Table A-10 (cont)
CO TWA Results (ppm) for Personal Samples
Collected at QMT [a]

Date	Shift	ID Number	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO	CO Concentration
8-5-81	3:00pm-11:00pm	C38-1	2:48pm/10.36pm	44552.3/46163.3	5.10	50	6.1
8-5-81	3:00pm-11:00pm	C7-1B	2:50pm/11:08pm	50345.8/52099.8	4.95	30	3.5
8-5-81	3:00pm-11:00pm	C39-1A	2:51pm/11:10pm	22112.2/24054.2	4.44	160	18.6
8-5-81	3:00pm-11:00pm	C40-1A	2:53pm/10:55pm	13529.2/15351.0	3.91	25	3.5
8-5-81	4:00pm-12:00am	C1-1B	3:20pm/11:40pm	29893.0/31012.0	4.25	150	31.5
8-5-81	4:00pm-12:00am	C6-1B	3:41pm/11:38pm	94170.1/96235.2	5.05	50	4.8
8-5-81	3:00pm-11:00pm	C26-1B	3:43pm/ 9:55pm	13840.2/15319.2	4.14	55	9.0
8-5/6-81	11:00pm- 7:00am	C42-1A	10:45pm/ 6:45am	08870.2/10337.2	4.57	75	11.0
8-5/6-81	11:00pm- 7:00am	C17-1C	10:53pm/ 7:00am	29896.8/30497.8	5.98	8	2.0
8-5/6-81	11:00pm- 7:00am	C41-1A	12:25am/ 6:08am	74649.3/76079.0	5.02	35	4.9
8-6/7-81	11:00pm- 7:00am	C43-1	10:35pm/ 6:55am	96235.0/98437.2	5.05	60	5.4
8-6/7-81	11:00pm- 7:00am	C17-1D	10:35pm/ 7:08am	46163.0/47626.3	5.10	25	3.4
8-6/7-81	11:00pm- 7:00am	C41-1B	10:40pm/ 7:08am	26622.0/27828.4	6.24	25	3.3
8-6/7-81	11:00pm- 7:00am	C16-1C	10:50pm/ 7:05am	52099.0/53679.9	4.95	40	5.1
8-6/7-81	11:00pm- 7:00am	C42-1B	11:10pm/ 7:00am	80269.0/82139.0	3.60	20	3.0
8-7-81	7:00am- 3:00pm	C45-1	6:15am/ 2:16pm	15374.3/17073.3	4.14	90	13.0
8-7-81	7:00am- 3:00pm	C32-1B	6:29am/ 1:42pm	06958.2/08182.1	4.72	70	12.0
8-7-81	7:00am- 3:00pm	C1-1C	6:40am/ 3:11pm	23479.9/24967.9	5.74	140	16.4
8-7-81	7:00am- 3:00pm	C46-1	6:45am/ 1:35pm	36272.5/37521.4	6.09	55	7.2
8-7-81	7:00am- 3:00pm	C47-1	6:45am/ 2:25pm	27896.9/29008.9	6.31	330	47.0
8-7-81	7:00am- 3:00pm	C48-1	6:50am/ 3:15pm	15394.2/17202.3	3.91	80	11.0
8-7-81	7:00am- 3:00pm	C29-1B	6:50am/ 3:05pm	71864.0/72486.1	5.68	25	7.1
8-7-81	7:00am- 3:00pm	C49-1	6:50am/ 2:03pm	30536.8/31479.8	5.98	95	17.0
8-7-81	7:00am- 3:00pm	C50-1	6:53am/ 3:12pm	76139.2/78313.4	5.01	100	9.2
8-7-81	7:00am- 3:00pm	C27-1B	6:53am/ 2:56pm	43107.1/44732.1	5.17	110	13.1
8-7-81	7:00am- 3:00pm	C33-1B	6:53am/ 1:26pm	10337.1/11520.2	4.57	70	13.0

Table A-10(cont)
CO TWA Results (ppm) for Personal Samples
Collected at QMT [a]

Date	Shift	ID Number	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO	CO Concentration
8-7-81	6:00am- 2:00pm	C39-1B	7:04am/ 1:55pm	47120.1/49690.6	5.96	260	17.0
8-7-81	7:00am- 3:00pm	C24-1C	7:33am/ 4:50pm	98441.2/00533.2	5.05	95	8.9
8-7-81	7:00am- 2:00pm	C28-1B	6:35am/ 1:44pm	20076.0/20580.4	3.84	50	26.0
8-7-81	2:00pm- 7:00pm	C28-1C	1:44pm/ 6:45pm	20580.4/22330.4	3.84	25	3.7
8-7-81	6:00am- 2:00pm	C30-1B	6:37am/ 1:46pm	13315.2/15213.3	4.64	75	8.5
8-7-81	2:00pm- 6:00pm	C30-1C	1:46pm/ 6:15pm	15213.3/16360.2	4.64	70	13.0
8-7-81	3:00pm-11:00pm	C51-1	2:32pm/10:33pm	47849.3/48402.3	5.10	80	28.0
8-7-81	3:00pm-11:00pm	C13-1B	2:35pm/11:07pm	27844.4/29060.4	6.24	45	5.9
8-7-81	3:00pm-11:00pm	C52-1	2:45pm/11:08pm	34701.0/36192.5	5.80	70	8.1
8-7-81	3:00pm-11:00pm	C53-1	2:48pm/11:06pm	38315.9/39787.7	5.71	70	8.3
8-7-81	3:00pm-11:00pm	C54-1	2:47pm/11:02pm	48862.7/50917.7	4.81	50	5.1
8-7-81	3:00pm-11:00pm	C8-1B	2:49pm/ 6:10pm	24080.2/24827.2	4.44	110	33.0
8-7-81	3:00pm-11:00pm	C55-1	2:50pm/11:04pm	28838.7/30240.7	5.61	100	12.7
8-7-81	3:00pm-11:00pm	C56-1	2:52pm/10:56pm	33220.0/35272.0	4.25	105	12.0
8-7-81	4:00pm-12:00am	C57-1	3:28pm/11:46pm	42133.8/42700.8	6.20	25	7.1
8-7-81	4:00pm-12:00am	C58-1	3:36pm/11:50pm	28980.1/30181.1	6.08	20	2.7
8-7-81	4:00pm-12:00am	C59-1	3:47pm/11:44pm	91016.2/92939.2	4.14	75	9.4
8-7-81	4:00pm-12:00am	C60-1	3:50pm/11:42pm	53887.8/55606.8	4.46	55	7.2
8-7-81	4:00pm-12:00am	C61-1	3:51pm/12:05am	87641.3/90299.4	3.79	50	5.0
8-7-81	7:00pm-11:00pm	C16-1D	6:50pm/11:05pm	44733.1/45402.1	5.17	30	8.7
8-7-81	4:00pm-12:00am	C9-1B	3:53pm/11:53pm	20108.4/21154.4	5.64	25	4.2
8-7-81	4:00pm-12:00am	C63-1	9:10pm/10:57pm	08183.2/08545.2	4.72	50	29.0

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

TABLE A-11

CO TWA Results (ppm) for Personal Samples
Collected At TB-M [a]

Date	Shift	ID Number	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO (Draeger)	CO Concentration
8-10-81	6:00am- 2:00pm	C71-1	7:10am/ 1:50pm	08545.0/09047.2	4.72	20	8.4
8-10-81	6:00am- 2:00pm	C73-1	7:20am/ 1:50pm	39787.0/40771.0	5.71	55	9.8
8-10-81	6:30am- 2:30pm	C72-1	7:15am/ 2:55pm	92939.0/94422.0	4.14	30	4.9
8-10-81	7:00am- 3:00pm	C64-1	6:45am/ 3:02pm	82450.0/84274.0	3.60	30	4.6
8-10-81	7:00am- 3:00pm	C65-1	6:45am/ 2:17pm	37525.0/38821.4	6.09	50	6.3
8-10-81	7:00am- 3:00pm	C66-1	9:50am/ 2:40pm	49722.0/51478.1	5.96	120	11.5
8-10-81	7:00am- 3:00pm	C68-1	6:50am/ 3:07pm	24967.0/26275.0	5.74	65	8.7
8-10-81	7:00am- 3:00pm	C69-1A	6:53am/ 2:13pm	50917.0/52394.7	4.81	40	5.6
8-10-81	7:00am- 3:00pm	C70-1A	6:55am/ 3:01pm	49402.0/50811.0	5.10	45	6.3
8-10-81	7:00am- 3:00pm	C74-1	7:33am/ 4:00pm	72487.0/73799.0	5.68	75	10.0
8-10-81	7:00am- 3:00pm	C75-1	7:40am/ 4:02pm	30240.0/31610.0	5.61	40	5.2
8-10-81	2:00pm-10:00pm	C83-1	2:58pm/ 9:45pm	40771.1/41231.0	5.71	10	3.8
8-10-81	3:00pm-11:00pm	C76-1	2:40pm/11:00pm	36192.0/37665.5	5.80	55	6.4
8-10-81	3:00pm-11:00pm	C77-1	2:40pm/10:26pm	17202.0/18847.0	3.91	40	6.2
8-10-81	3:00pm-11:00pm	C78-1A	2:40pm/10:25pm	11520.0/12958.0	4.57	40	6.1
8-10-81	3:00pm-11:00pm	C79-1A	2:40pm/11:08pm	31479.0/32958.8	5.98	45	5.1
8-10-81	3:00pm-11:00pm	C80-1A	2:50pm/10:25pm	17076.3/18797.3	4.14	45	6.3
8-10-81	3:00pm-11:00pm	C81-1A	2:50pm/10:05pm	30131.9/31196.9	6.31	50	7.4
8-10-81	3:00pm-11:00pm	C82-1A	2:50pm/11:05pm	38821.4/40385.5	6.09	60	6.3
8-11-81	2:00pm-10:00pm	C84-1A	2:55pm/ 9:35pm	51478.0/54203.0	5.96	140	8.6
8-11-81	3:00pm-11:00pm	C78-1B	2:40pm/11:10pm	73800.0/76116.0	5.68	25	1.9

TABLE A-11(cont)

CO TWA Results (ppm) for Personal Samples
Collected At TB-M [(a)]

Date	Shift	ID Number	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO (Draeger)	CO Concentration
8-11-81	3:00pm-11:00pm	C81-1B	2:45pm/10:08pm	31610.7/32533.7	5.61	25	4.8
8-11-81	3:00pm-11:00pm	C79-1B	2:52pm/10:20pm	84274.0/85958.0	3.60	45	7 4
8-11-81	3:00pm-11:00pm	C85-1A	2:55pm/10:50pm	50811.3/51536.3	5.10	20	5.4
8-11-81	3:00pm-11:00pm	C87-1	3:05pm/ 9:40pm	26275.9/26670.0	5.74	10	4.4
8-11-81	3:00pm-11:00pm	C89-1	3:30pm/10:10pm	52394.8/53303.8	4.81	45	10.0
8-11-81	4:00pm-12:00am	C90-1	3:55pm/10:20pm	22330.5/23547.5	3.84	50	11.0
8-11-81	4:00pm-12:00am	C91-1	3:40pm/11:40pm	30181.1/30778.1	6.08	15	4.1
8-11-81	4:00pm-12:00am	C92-1	3:55pm/10:21pm	09047.2/09589.2	4.72	20	7.8
8-11/12-81	11:00pm- 7:00am	C95-1A	10:50pm/ 7:05am	18848.3/20584.2	3.91	20	1.0
8-11/12-81	11:00pm- 7:00am	C96-1A	10:50pm/ 6:45am	90299.4/92724.8	3.79	60	6.5
8-11/12-81	10:30pm- 6:30am	C86-1B	10:55pm/ 6:42am	45414.1/46238.1	5.17	5	1.0
8-11/12-81	11:00pm- 7:00am	C85-1B	10:55pm/ 6:55am	18512.2/20529.3	4.64	90	9.6
8-12/13-81	11:00pm- 7:00am	C85-1C	10:45pm/ 7:10am	32537.7/33625.7	5.61	20	3.3
8-12/13-81	11:00pm- 7:00am	C96-1B	10:45pm/ 7:12am	85961.6/87844.0	3.60	30	4.4
8-12/13-81	11:00pm- 7:00am	C95-1B	10:50pm/ 7:15am	20584.2/22339.2	3.91	25	3.6
8-12/13-81	10:30pm- 6:30am	C86-1C	10:50pm/ 6:35am	09594.2/09937.1	4.72	5	3.0
8-13-81	7:00am- 3:00pm	C69-1B	6:30am/ 2:57pm	30381.4/32272.4	6.24	20	1.7
8-13-81	7:00am- 3:00pm	C97-1	6:30am/ 3:03pm	40388.4/41519.4	6.09	25	3.6
8-13-81	7:00am- 3:00pm	C70-1B	6:35am/ 2:38pm	32963.8/34157.8	5.98	55	7.7
8-13-81	7:00am- 3:00pm	C82-1B	6:35am/ 3:06pm	54224.0/54608.0	5.96	10	4.4

TABLE A-11(cont)

CO TWA Results (ppm) for Personal Samples Collected At TB-M [a]

Date	Shift	ID Number	Sampling Time On/Off	Strokes On/Off	cc/Stroke	uL CO (Draeger)	CO Concentration
8-13-81	7:00am- 3:00pm	C80-1B	6:45am/ 2:55pm	21158.4/21691.4	5.64	25	8.3
8-13-81	7:00am- 3:00pm	C98-1	6:45am/ 2:55pm	81413.3/82994.2	5.01	45	5.7
8-13-81	7:00am- 3:00pm	C99-1	6:45am/ 2:33pm	12967.1/14200.1	4.57	50	8.9
8-13-81	7:00am- 3:00pm	C100-1	6:55am/ 2:50pm	51541.3/52119.3	5.10	20	6.8
8-13-81	7:00am- 3:00pm	C84-1B	7:50am/ 4:15pm	20529.3/22824.5	4.64	110	10.4

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

Table A-12

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-100 ppm

			Number of Peaks Found at Various CO Concentrations (ppm)			
Location	Date	Time	<35	≥35	≥50	≥100
QMT Lane 7	8/3/81	4:30 - 5 p.m.			7	
		5:00 - 6 p.m.			13	
		6:00 - 7 p.m.		1	19	
		7:00 - 8 p.m.		4	15	
		8:00 - 9 p.m.		3	14	
		9:00 -10 p.m.		4	15	
		10:00 -11 p.m.			18	
		11:00 -11:18 p.m.		1	4	
QMT Lane 5	8/3/81	7:00 - 8 p.m.	3	6	7	
		8:00 - 9 p.m.	1		12	
		9:00 -10 p.m.		3	12	
		10:00 -11 p.m.		6	8	
		11:00 -11:20 p.m.	3	1	1	
QMT Canopy	8/4/81	9:20 -10 a.m.	7			
		10:00 -11 a.m.	8			
		11:00 -12 noon	8			
		12:00 - 1 p.m.	5			
		1:00 - 2 p.m.	20			
		2:00 - 3 p.m.	25			
QMT Catwalk Booth (41)	8/4/81	9:00 - 9:30 a.m.	5			
QMT Catwalk (N-4)	8/4/81	9:30 -10 a.m.	22	4	1	
QMT Canopy	8/4/81	9:20 -10 a.m.	7			
		10:00 -11 a.m.	8			
		11:00 -12 noon	8			
		12:00 - 1 p.m.	5			
		1:00 - 2 p.m.	20			
		2:00 - 3 p.m.	21			

Table A-12 (cont.)

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-100 ppm

Location	Date	Time	Number of Peaks Found at Various CO Concentrations (ppm) <35	≥35	≥50	≥100
QMT Booth 7	8/5/81	8:30 - 9 a.m.	7	1		
		9:00 -10 a.m.	10	1		
		10:00 -11 a.m.	7			
		11:00 -12 noon	10			
		12:00 - 1 p.m.	9			
		1:00 - 2 p.m.	12			
		2:00 - 3 p.m.	10			
		3:00 - 4 p.m.	8			
		4:00 - 5 p.m.	8			
		5:00 - 6 p.m.	6			
		6:00 - 7 p.m.	7			
		7:00 - 8 p.m.	6			
		8:00 - 9 p.m.	8			
		9:00 -10 p.m.	4			
		10:00 -11 p.m.	6			
		11:00 -12 midnight	7			
QMT Catwalk (N-4)*	8/5/81	9:00 -10 a.m.			16	
		10:00 -11 a.m.			12	
		11:00 -12 noon			18	**
		12:00 - 1 p.m.			14	
		1:00 - 2 p.m.			13	**
QMT Booth 7	8/7/81	2:05 - 3 a.m.	5			
		3:00 - 4 a.m.	2			
		4:00 - 5 a.m.	4			
		5:00 - 6 a.m.	5			
		6:00 - 7 a.m.	7			
		7:00 - 8 a.m.	6			
		8:00 - 9 a.m.	9			
		9:00 -10 a.m.	5			
		10:00 -11 a.m.	7			
		11:00 -12 noon	11			
		12:00 - 1 p.m.	14			
		1:00 - 2 p.m.	7			
		2:00 - 3 p.m.	6			
		5:30 - 6 p.m.	3			
		6:00 - 7 p.m.	2			

* Peaks below 50 ppm not read.

** Ecolyzer off scale 2 minutes (11 a.m. - 12 noon) and 3 minutes (1 p.m. - 2 p.m.) indicating CO concentration >100 ppm.

Table A-12 (cont.)

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-100 ppm

Location	Date	Time	Number of Peaks Found at Various CO Concentrations (ppm)			
			<35	≥35	≥50	≥100
TB-M Booth 10	8/10/81	4:00 - 5 p.m.	5	2	1	
		5:00 - 6 p.m.	5			
		6:00 - 7 p.m.	7	2	1	
		7:00 - 8 p.m.	6	1		
		8:00 - 9 p.m.	8	1	1	
		9:00 -10 p.m.	9	2	3	
TB-M Booth 5	8/11-12/81	9:00 -10 p.m.	7	1	3	
		10:00 -11 p.m.	3			
		11:00 -12 midnight	8			
		12:00 - 1 a.m.	6			
		1:00 - 2 a.m.	5			
		2:00 - 3 a.m.	5			
		3:00 - 4 a.m.	2	1		
		4:00 - 5 a.m.	2			
		5:00 - 6 a.m.	2			
		6:00 - 7 a.m.	8		1	
TB-M Lane 12	8/12/81	11:00 -12 midnight	7			
		12:00 - 1 a.m.	8			
TB-M Canopy (by intake)	8/11-12/81	4:30 - 5 p.m.	8			
		5:00 - 6 p.m.	10			
		6:00 - 7 p.m.	1			
		7:00 -10 p.m.	no peaks			
		10:00 -11 p.m.	8			
		11:00 -12 midnight	4			
		12:00 - 3:30 a.m.	no peaks			
		3:30 - 4 a.m.	4			
		4:00 - 5 a.m.	16			
TB-M Booth 12*	8/12-13/81	11:00 -12 midnight	2			
		12:00 - 1 a.m.	5		1	
		1:00 - 2 a.m.	1			
		2:00 - 3 a.m.	1			

* No peaks > 14 ppm read

Table A-13

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-600 ppm

Location Time	Date	Number of Peaks Found at Various CO Concentrations (ppm) <35	≥35	≥50	≥100	≥200	≥300	≥400	Comments
QMT Lane 7	8/4/81								
7:20 - 8 a.m.				1	7		2		
8:00 - 9 a.m.				3	9	5	1		
9:00 -10 a.m.			1	3	10	3			
10:00 -11 a.m.				7	3	3	1		
11:00 -12 noon				7		1			
12:30 - 1 p.m.				3	6				
1:00 - 2 p.m.				3	10	3			
2:00 - 3 p.m.				6	11	1			
QMT Lane 3	8/4/81								
7:10 - 8 a.m.				2	11	1		1	
8:00 - 9 a.m.				2	12	7			
9:00 -10 a.m.				1	10	5	1		
10:00 -11 a.m.				1	14	2			
11:00 -12 noon				1	9	1	2		
12:00 - 1 p.m.					12	3	2	1	
1:00 - 2 p.m.					12	3	2		
2:00 - 3 p.m.					13	1	2		

Table A-13 (cont.)

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-600 ppm

Location / Time	Date	Number of Peaks Found at Various CO Concentrations (ppm) <35	≥35	≥50	≥100	≥200	≥300	≥400	COMMENTS
QMT Catwalk (S-1)	8/5/81								
2:00 - 3 p.m.				7	6				
3:00 - 4 p.m.				4	18(a)	1			
4:00 - 5 p.m.					16				
5:00 - 6 p.m.					13(a)	1			
6:00 - 7 p.m.					15(a)				
7:00 - 8 p.m.					6(a)				
8:00 - 9 p.m.					12(a)				Approximately, 13 minutes of 200 ppm w/high of 375 ppm.
9:00 - 9:45 p.m.					7(a)				
QMT Lane 7*	8/5/81								
8:30 - 9 a.m.				1	5				
9:00 -10 a.m.			2	8	5				
10:00 -11 a.m.		1	2	13					
11:00 -12 noon			1	10					
12:00 - 1 p.m.		1	2	7					
1:00 - 2 p.m.			4	3					
2:00 - 3 p.m.				8					
3:00 - 4 p.m.		2	1	6					
4:00 - 5 p.m.			3	4					

(a) At various times peak concentrations were reached and held for 0.5 - 1.5 minutes.
* Scale changed to 0-100 ppm at 10 a.m.

Table A-13 (cont.)

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-600 ppm

Location / Time	Date	Number of Peaks Found at Various CO Concentrations (ppm) <35	≥35	≥50	≥100	≥200	≥300	≥400	COMMENTS
QMT Lane 5	8/7/81								
Midnight - 1 a.m.					7	3	1	1	only peaks ≥100 ppm read
1:30 - 2 a.m.				2	1	1			only peaks ≥80 ppm read
2:00 - 3 a.m.				2	1	1			" "
3:00 - 4 a.m.				6	1		1		only peaks ≥60 ppm read
4:00 - 5 a.m.				7	1				" "
5:00 - 6 a.m.				6	3	1			" "
6:00 - 6:30 a.m.				5					" "
6:30 - 7 a.m.				3		1			only peaks ≥80 ppm read
7:00 - 8 a.m.				4	7	1			" "
8:00 - 9 a.m.				3	2	1			" "
9:45 -11 a.m.				2	5		2	1	" "
11:00 -12 noon				6	2	2			" "
12:00 - 1 p.m.				5	1	1	1		" "
1:00 - 2 p.m.				7	6				" "
2:00 - 3 p.m.				4	1				" "
3:00 - 4 p.m.				2					" "
4:00 - 4:45 p.m.				7					" "
QMT Lane 7	8/7/81								
5:00 - 6 p.m.				2	1				only peaks ≥50 ppm read
6:00 - 7 p.m.				12					" "
7:30 - 8 p.m.				10	2				not all peaks ≥70 ppm read
8:00 - 9 p.m.				15	1				
9:00 -10 p.m.				15	2				
10:00 -11 p.m.				21	6				
11:00 -12 midnight				17	5				
12:00 -12:15 a.m.				3	2	1			

Table A-13 (cont.)

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-600 ppm

Location / Time	Date	Number of Peaks Found at Various CO Concentrations (ppm) <35	≥35	≥50	≥100	≥200	≥300	≥400	COMMENTS
TB-M Booth 10*	8/10/81								
7:30 - 8 a.m.				7	3				75-180 ppm for 4 minutes
8:00 - 9 a.m.		2	8	9					
9:00 -10 a.m.		5	10	2					
10:00 -11 a.m.		5	12	4					
11:00 -12 noon		6	7	8					
12:00 - 1 p.m.		3	2	3					
1:00 - 2 p.m.		1	2	3					
2:00 - 3 p.m.		5	2						
3:00 - 4 p.m.		3							
TB-M Lane 10	8/10/81								
7:15 - 8 a.m.					5	2	1		
8:00 - 9 a.m.				1	12	5	2		
9:00 -10 a.m.					18				
10:00 -11 a.m.				1	12	4	1		
11:00 -12 noon					7	6	1	1	
12:00 - 1 p.m.				1	8	4	2		
1:00 - 2 p.m.				1	9	2			
2:00 - 3 p.m.				1	9	1	1		
3:00 - 4 p.m.				2	7	2	3		
4:00 - 5 p.m.				3	8	6	1		
5:00 - 6 p.m.				1	7	1			
6:00 - 7 p.m.				1	8	1			
7:00 - 8 p.m.				1	6	1			
8:00 - 9 p.m.				5	4				
9:00 -10 p.m.				7	1				

* Scale changed to 0-100 ppm at 8 a.m.

Table A-13 (cont.)

Peak CO Values Collected at TBTA

Ecolyzer Scale: 0-600 ppm

Location / Time	Date	<35	≥35	≥50	≥100	≥200	≥300	≥400	COMMENTS
TB-M Lane 5	8/11-12/81								
4:00 - 5 p.m.				6	10				
5:00 - 6 p.m.				2	13				
6:00 - 7 p.m.				4	6				
8:30 - 9 p.m.					5	1	1		
9:00 -10 p.m.				3	8	1			
10:00 -11 p.m.				4	8	1			
11:00 -12 midnight				3	11				
12:00 - 1 a.m.				1	9	2	1		
1:00 - 2 a.m.				1	11				
2:00 - 3 a.m.				2	10				
3:00 - 4 a.m.				3	3				
4:00 - 5 a.m.				1	3	2			
5:00 - 6 a.m.				1	4	4			
6:00 - 7 a.m.				4	4	2			
TB-M Lane 12	8/12-13/81								
11:15 - 12 Midnight					16	2	2		only peaks ≥100 ppm read
12:00 - 1 a.m.				1	7	4			
1:00 - 2 a.m.				5	3				
2:00 - 3 a.m.				6			1		
3:00 - 4 a.m.				5	4	2	1		
4:00 - 5 a.m.				6	5	1	2	1	
5:00 - 6 a.m.				5	11	1	4		
6:00 - 7 a.m.				1	10	2	3		
7:00 - 8 a.m.				1	12	9	6		
8:00 - 9 a.m.				2	15	7	4		
9:00 -10 a.m.				1	16	6			
10:00 -11 a.m.				2	10	3	2		
11:00 -12 noon				1	17	3			
12:00 - 1 p.m.				2	13	1	1		
1:00 - 2 p.m.				6	9	2	1		
2:00 - 3 p.m.				5	15	6	2		

TABLE A-14

CO Breath Analysis Results (% COHb) and Smoking Histories for BTO's Working at QMT [(a)]

Date	Shift	ID Number	Preshift Breath CO (ppm)	Preshift % Carboxy-hemoglobin	Postshift Breath CO (ppm)	Postshift % Carboxy-hemoglobin	Smoking History
8-3-81	4:00pm-12:00am	C1-1A	26.0	5.7	25.2	5.54	Yes
8-3-81	4:00pm-12:00am	C2-1A	24.8	5.46	26.0	5.70	Yes
8-3-81	4:00pm-12:00am	C3-1	6.5	1.8	8.5	2.2	No
8-3-81	4:00pm-12:00am	C4-1A	5.5	1.6	5.8	1.7	No
8-3-81	4:00pm-12:00am	C5-1	6.0	1.7	16.0	3.7	No
8-3-81	4:00pm-12:00am	C6-1A	6.4	1.8	7.2	1.9	No
8-3-81	4:00pm-12:00am	C7-1A	9.0	2.3	6.8	1.9	No
8-3-81	4:00pm-12:00am	C8-1A	11.8	2.86	19.0	4.3	No
8-3-81	4:00pm-12:00am	C9-1A	5.0	1.5	5.0	1.5	No
8-3-81	3:00pm-11:00pm	C10-1	9.0	2.3	8.0	2.1	No
8-3-81	3:00pm-11:00pm	C11-1A	6.0	1.7	8.0	2.1	No
8-3-81	3:00pm-11:00pm	C12-1A	35.5	7.6	35.0	7.5	Yes
8-4-81	7:00am- 3:00pm	C14-1	3.4	1.2	7.4	2.0	No
8-4-81	7:00am- 3:00pm	C15-1	3.8	1.3	8.2	2.1	No
8-4-81	7:00am- 3:00pm	C16-1A	46.0	9.7	36.9	7.88	Yes
8-4-81	7:00am- 3:00pm	C17-1A	5.4	1.6	9.5	2.4	No
8-4-81	6:00am- 2:00pm	C18-1	3.2	1.1	9.0	2.3	No
8-4-81	7:00am- 3:00pm	C19-1	21.0	4.7	28.0	6.1	Yes
8-4-81	7:00am- 3:00pm	C20-1	5.4	1.6	8.8	2.3	No
8-4-81	7:00am- 3:00pm	C21-1	27.0	5.9	18.8	4.26	No
8-4-81	7:00am- 3:00pm	C22-1	5.4	1.6	9.0	2.3	Yes
8-4-81	8:00am- 4:00pm	C23-1	5.5	1.6	6.2	1.7	No

TABLE A-14 (cont)

CO Breath Analysis Results (% COHb) and Smoking Histories for BTO's Working at QMT [a]

Date	Shift	ID Number	Preshift Breath CO (ppm)	Preshift % Carboxy-hemoglobin	Postshift Breath CO (ppm)	Postshift % Carboxy-hemoglobin	Smoking History
8-4-81	8:00am- 4:00pm	C24-1A	4.8	1.5	9.6	2.4	No
8-4-81	8:00am- 4:00pm	C26-1A	14.2	3.3	17.0	3.9	Yes
8-4-81	8:00am- 4:00pm	C27-1A	7.0	1.9	7.5	2.	No
8-5-81	7:00am- 3:00pm	C29-1A	5.4	1.6	7.5	2.0	No
8-5-81	7:00am- 3:00pm	C30-1A	4.8	1.5	8.2	2.1	No
8-5-81	7:00am- 3:00pm	C31-1	21.6	4.8	20.5	4.6	Yes
8-5-81	7:00am- 3:00pm	C32-1A	5.4	1.6	10.8	2.7	No
8-5-81	7:00am- 3:00pm	C17-1B	6.8	1.9	10.0	2.5	No
8-5-81	7:00am- 3:00pm	C33-1A	5.6	1.6	9.9	2.5	No
8-5-81	7:00am- 3:00pm	C34-1	8.0	2.1	12.8	3.1	Yes
8-5-81	7:00am- 3:00pm	C35-1	20.0	4.5	13.7	3.2	Yes
8-5-81	8:00am- 4:00pm	C24-1B	6.8	1.9	9.8	2.5	No
8-5-81	8:00am- 4:00pm	C36-1	13.2	3.1	13.8	3.3	No
8-5-81	8:00am- 4:00pm	C37-1	5.6	1.6	10.8	2.7	No
8-5-81	3:00pm-11:00pm	C13-1A	6.6	1.8	8.0	2.1	No
8-5-81	3:00pm-11:00pm	C11-1B	6.4	1.8	8.6	2.2	No
8-5-81	3:00pm-11:00pm	C12-1B	17.4	4.0	9.4	2.4	Yes
8-5-81	3:00pm-11:00pm	C38-1	8.6	2.2	15.8	3.7	No
8-5-81	3:00pm-11:00pm	C7-1B	8.6	2.2	6.4	1.8	No
8-5-81	3:00pm-11:00pm	C39-1A	15.4	3.6	10.6	2.6	Yes
8-5-81	3:00pm-11:00pm	C40-1A	8.0	2.1	8.6	2.2	No
8-5-81	4:00pm-12:00am	C1-1B	15.6	3.6	21.8	4.9	Yes
8-5-81	4:00pm-12:00am	C2-1B	22.4	5.0	30.0	6.5	Yes

TABLE A-14 (cont)

CO Breath Analysis Results (% COHb) and Smoking Histories for BTO's Working at QMT [(a)]

Date	Shift	ID Number	Preshift Breath CO (ppm)	Preshift % Carboxy-hemoglobin	Postshift Breath CO (ppm)Co	Postshift % Carboxy-hemoglobin	Smoking History
8-5-81	4:00pm-12:00am	C6-1B	6.4	1.8	9.0	2.3	No
8-5-81	3:00pm-11:00pm	C26-1B	22.0	4.9	26.0	5.7	Yes
8-5/6-81	11:00pm- 7:00am	C42-1A	12.8	3.1	9.2	2.3	No
8-5/6-81	11:00pm- 7:00am	C16-1B	40.2	8.5	40.6	8.6	Yes
8-5/6-81	11:00pm- 7:00am	C17-1C	9.0	1.8	5.8	1.2	No
8-5/6-81	11:00pm- 7:00am	C41-1A	5.4	1.1	6.8	1.4	No
8-6/7-81	11:00pm- 7:00am	C43-1	5.0	1.5	4.4	1.4	No
8-6/7-81	11:00pm- 7:00am	C17-1D	7.0	2.0	7.6	2.0	No
8-6/7-81	11:00pm- 7:00am	C41-1B	8.2	2.1	7.6	2.0	No
8-6/7-81	11:00pm- 7:00am	C16-1C	38.0	8.1	39.8	8.5	Yes
8-6/7-81	11:00pm- 7:00am	C44-1	8.0	2.0	8.8	2.3	No
8-6/7-81	11:00pm- 7:00am	C42-1B	9.0	2.3	9.0	2.3	No
8-7-81	7:00am- 3:00pm	C45-1	9.6	2.4	13.5	3.2	Yes
8-7-81	7:00am- 3:00pm	C32-1B	7.4	2.0	10.6	2.62	No
8-7-81	7:00am- 3:00pm	C1-1C	13.0	3.1	16.4	3.78	Yes
8-7-81	7:00am- 3:00pm	C46-1	38.0	8.1	47.2	9.94	Yes
8-7-81	7:00am- 3:00pm	C47-1	20.8	4.7	37.2	7.94	Yes
8-7-81	7:00am- 3:00pm	C48-1	5.6	1.6	12.2	2.94	
8-7-81	7:00am- 3:00pm	C29-1B	5.8	1.7	9.0	2.3	No
8-7-81	7:00am- 3:00pm	C49-1	7.0	1.9	9.4	2.4	
8-7-81	7:00am- 3:00pm	C50-1	29.8	6.5	32.8	7.06	Yes
8-7-81	7:00am- 3:00pm	C27-1B	6.0	1.7	12.4	2.98	No
8-7-81	7:00am- 3:00pm	C33-1B	6.2	1.7	9.5	2.4	No
8-7-81	6:00am- 2:00pm	C39-1B	10.8	2.7	12.4	2.98	Yes

TABLE A-14 (cont)

CO Breath Analysis Results (% COHb) and Smoking Histories for BTO's Working at QMT [(a)]

Date	Shift	ID Number	Preshift Breath CO (ppm)	Preshift % Carboxy-hemoglobin	Postshift Breath CO (ppm)Co	Postshift % Carboxy-hemoglobin	Smoking History
8-7-81	7:00am- 3:00pm	C24-1C	5.6	1.6	13.6	3.2	No
8-7-81	7:00am- 2:00pm	C28-1B	30.2	6.54	60.8	12.7	Yes
8-7-81	2:00pm- 7:00pm	C28-1C	60.8	12.7	58.6	12.2	Yes
8-7-81	6:00am- 2:00pm	C30-1B	7.0	1.9	9.2	2.3	No
8-7-81	2:00pm- 6:00pm	C30-1C	9.2	2.3	10.4	2.6	No
8-7-81	3:00pm-11:00pm	C51-1	7.0	1.9	12.4	3.0	No
8-7-81	3:00pm-11:00pm	C13-1B	7.0	1.9	25.4	5.6	No
8-7-81	3:00pm-11:00pm	C52-1	39.0	8.3	82.0	16.9	Yes
8-7-81	3:00pm-11:00pm	C53-1	9.6	2.4	19.4	4.4	Yes
8-7-81	3:00pm-11:00pm	C54-1	18.4	4.2	17.2	3.9	Yes
8-7-81	3:00pm-11:00pm	C8-1B	12.4	3.0	9.6	2.4	No
8-7-81	3:00pm-11:00pm	C55-1	35.2	7.5	50.2	10.5	Yes
8-7-81	3:00pm-11:00pm	C56-1	24.2	5.3	29.5	6.4	Yes
8-7-81	4:00pm-12:00am	C57-1	39.0	8.3	40.0	8.5	Yes
8-7-81	4:00pm-12:00am	C58-1	7.2	1.9	8.6	2.2	No
8-7-81	4:00pm-12:00am	C59-1	7.2	1.9	13.4	3.2	No
8-7-81	4:00pm-12:00am	C60-1	10.8	2.7	11.0	2.7	No
8-7-81	4:00pm-12:00am	C61-1	9.6	2.4	8.0	2.1	No
8-7-81	7:00pm-11:00pm	C16-1D	29.8	6.5	46.8	10.0	Yes
8-7-81	4:00pm-12:00am	C9-1B	7.2	1.9	9.0	2.3	No
8-7-81	4:00pm-12:00am	C63-1	8.6	2.2	14.8	3.5	No

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

TABLE A-15

CO Breath Analysis Results (% COHb) and
Smoking Histories for BTO's Working at TB-M Toll Plaza

Date	Shift	ID Number	Preshift Breath CO (ppm)	Preshift % Carboxy-hemoglobin	Postshift Breath CO (ppm)	Postshift % Carboxy-hemoglobin	Smoking History
8-10-81	6:00am- 2:00pm	C71-1	28.0	6.1	29.5	6.4	Yes
8-10-81	6:30am- 2:30pm	C72-1	6.0	1.7	9.0	2.3	No
8-10-81	7:00am- 3:00pm	C64-1	6.0	1.7	7.0	1.9	No
8-10-81	7:00am- 3:00pm	C65-1	38.0	8.1	33.0	7.1	Yes
8-10-81	7:00am- 3:00pm	C66-1	59.0	12.3	54.0	11.3	Yes
8-10-81	7:00am- 3:00pm	C67-1	7.0	1.9	10.0	2.5	No
8-10-81	7:00am- 3:00pm	C68-1	29.0	6.3	47.5	10.0	Yes
8-10-81	7:00am- 3:00pm	C69-1A	8.0	2.1	9.0	2.3	No
8-10-81	7:00am- 3:00pm	C70-1A	25.0	5.5	31.0	6.7	Yes
8-10-81	7:00am- 3:00pm	C74-1	49.0	10.3	8.0	10.7	Yes
8-10-81	7:00am- 3:00pm	C75-1	10.0	2.5	51.0	2.1	Yes
8-10-81	2:00pm-10:00pm	C83-1	6.0	1.7	9.0	2.3	No
8-10-81	3:00pm-11:00pm	C76-1	6.0	1.7	11.0	2.7	No
8-10-81	3:00pm-11:00pm	C77-1	27.0	5.9	38.0	8.1	Yes
8-10-81	3:00pm-11:00pm	C78-1A	7.0	1.9	9.0	2.3	No
8-10-81	3:00pm-11:00pm	C79-1A	6.0	1.7	9.0	2.3	No
8-10-81	3:00pm-11:00pm	C80-1A	32.0	6.9	40.0	8.5	Yes
8-10-81	3:00pm-11:00pm	C81-1A	7.0	1.9	11.0	2.7	No
8-10-81	3:00pm-11:00pm	C82-1A	7.5	2.0	11.0	2.7	No
8-11-81	3:00pm-11:00pm	C78-1B	7.5	2.0	8.0	2.1	No
8-11-81	3:00pm-11:00pm	C81-1B	9.0	2.3	9.0	2.3	No
8-11-81	3:00pm-11:00pm	C79-1B	8.0	2.1	7.0	1.9	No
8-11-81	3:00pm-11:00pm	C85-1A	25.5	5.6	24.0	5.3	Yes
8-11-81	2:30pm-10:30pm	C86-1A	37.5	8.0	47.0	9.9	Yes

TABLE A-15 (cont)
CO Breath Analysis Results (% COHb) and
Smoking Histories for BTO's Working at TB-M Toll Plaza

Date	Shift	ID Number	Preshift Breath CO (ppm)	Preshift % Carboxy-hemoglobin	Postshift Breath CO (ppm)	Postshift % Carboxy-hemoglobin	Smoking History
8-11-81	3:00pm-11:00pm	C87-1	8.0	2.1	9.0	2.3	No
8-11-81	3:00pm-11:00pm	C89-1	10.0	2.5	11.0	2.7	No
8-11-81	4:00pm-12:00am	C90-1	8.0	2.1	11.5	2.8	No
8-11-81	4:00pm-12:00am	C91-1	30.5	6.6	39.0	8.3	Yes
8-11-81	4:00pm-12:00am	C92-1	16.0	3.7	10.0	2.5	No
8-11/12-81	11:00pm- 7:00am	C95-1A	8.0	2.1	6.5	1.8	No
8-11/12-81	11:00pm- 7:00am	C96-1A	5.5	1.6	11.0	2.7	No
8-11/12-81	10:30pm- 6:30am	C86-1B	24.0	5.3	42.0	8.9	Yes
8-11/12-81	11:00pm- 7:00am	C85-1B	47.0	9.9	45.5	9.6	Yes
8-12/13-81	11:00pm- 7:00am	C85-1C	34.0	7.3	38.0	8.1	Yes
8-12/13-81	11:00pm- 7:00am	C96-1B	7.5	2.0	8.0	2.0	No
8-12/13-81	11:00pm- 7:00am	C95-1B	6.5	1.8	8.0	2.0	No
8-12/13-81	10:30pm- 6:30am	C86-1C	14.0	3.3	9.5	2.4	Yes
8-13-81	7:00am- 3:00pm	C69-1B	6.0	1.7	7.0	1.9	No
8-13-81	7:00am- 3:00pm	C97-1	17.0	3.9	13.5	3.2	Yes
8-13-81	7:00am- 3:00pm	C70-1B	31.0	6.7	27.0	5.9	Yes
8-13-81	7:00am- 3:00pm	C82-1B	6.0	1.7	10.0	2.5	No
8-13-81	7:00am- 3:00pm	C79-1C	7.0	1.9	7.0	1.9	No
8-13-81	7:00am- 3:00pm	C80-1B	26.0	5.7	30.0	6.5	Yes
8-13-81	7:00am- 3:00pm	C98-1	46.0	9.7	45.5	9.6	Yes
8-13-81	7:00am- 3:00pm	C99-1	8.5	2.2	11.0	2.7	No
8-13-81	7:00am- 3:00pm	C100-1	7.0	1.9	10.5	2.6	No

a) Data have not been corrected for temperature and pressure variation; maximum deviation would be within $\pm$ 2% of actual values.

Table A-16

Distribution of Personal CO and COHb Data
Collected at QMT and TB 8/3 - 13/81

Variable	Skewness	Kurtosis	Test for Normality (p)
CO	2.95	11.14	<0.01
ln (CO)	0.12	0.94	>0.15
Pre-COHb	1.48	1.58	<0.01
ln (Pre-COHb)	0.70	-0.79	<0.01
Post-COHb	1.63	2.35	<0.01
ln (Pos-COHb)	0.80	-0.54	<0.01

Table A-17

Distribution of Area CO
Data Collected at QMT and TB 8/3 - 13/81

Variable	Skewness	Kurtosis	Test for Normality (p)
Total			
CO	1.87	5.41	<0.01
ln (CO)	-0.44	-0.34	<0.01
Draeger			
CO	0.64	0.23	0.07
ln (CO)	-0.90	0.12	0.02
Ecolyzer			
CO	1.65	3.40	<0.01
ln (CO)	-0.14	-0.92	0.48

Table A-18

Summary Statistics of Area CO Data
Collected at the QMT and TB 8/3 - 13/81

	Statistics:					95% Confidence Limits of Geometric Mean	
Group	n	Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation	Upper	Lower
Entire Sample	61	26.23	22.14	18.25	2.53	23.14	14.40
Draeger	31	22.22	14.77	16.45	2.46	22.87	11.84
Bridge	15	22.94	9.08	21.01	1.58	27.07	16.30
Tunnel	16	21.55	18.93	13.09	3.13	24.03	7.13
Ecolyzer	30	30.37	27.46	20.32	2.61	29.05	14.21
Bridge	12	30.88	24.00	20.18	2.97	40.29	10.11
Tunnel	18	30.02	30.22	20.41	2.45	31.83	13.08
Tunnel (Draeger)							
Plaza	7	15.31	11.79	10.99	2.57	26.36	4.58
Tunnel Int.	9	26.40	22.52	14.99	3.72	41.27	5.45
Tunnel (Ecolyzer)							
Plaza	14	24.91	20.05	19.06	2.14	29.55	12.29
Tunnel Int.	4	47.90	53.72	25.93	4.01	236.01	2.85

Table A-19

Summary Statistics of Personal CO Data
Collected at the QMT and TB 8/3 - 13/81

Group	Statistics: n	Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation	95% Confidence Limits of Geometric Mean: Upper	Lower
Entire Sample	117	8.14	6.86	6.43	1.96	7.27	5.68
Smokers	45	9.30	8.21	7.24	1.99	8.92	5.88
Non-smokers	70	7.23	5.75	5.83	1.91	6.80	4.99
Bridge	46	6.17	2.64	5.47	1.76	6.46	4.63
Smokers	19	6.35	2.69	5.64	1.76	7.40	4.29
Non-smokers	27	6.06	2.65	5.35	1.76	6.70	4.27
Tunnel	71	9.42	8.32	7.14	2.06	8.47	6.02
Smokers	26	11.45	10.10	8.70	2.06	11.66	6.49
Non-smokers	43	7.97	6.97	6.15	2.01	7.62	4.96
Tunnel							
Plaza	26	6.38	6.15	5.02	1.89	6.49	3.89
Tunnel Int	40	11.28	8.98	8.95	1.96	11.08	7.23

Table A-20

Summary Statistics of COHb Data
Collected at the QMT and TB 8/3 - 13/81

Group	Variable	n	Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation	95% Confidence Limits of Geometric Mean Upper	95% Confidence Limits of Geometric Mean Lower
Total	Pre-COHb	139	3.54	2.53	2.88	1.84	3.19	2.60
	Post-COHb	136	4.13	2.96	3.39	1.81	3.75	3.07
	Change in COHb	136	0.61	1.29				
Bridge	Pre-COHb	49	4.11	2.80	3.34	1.89	4.01	2.78
	Post-COHb	46	4.55	3.09	3.70	1.88	4.46	3.06
	Change in COHb	46	0.47	1.02				
Tunnel	Pre-COHb	90	3.23	2.33	2.66	1.80	3.01	2.35
	Post-COHb	90	3.91	2.88	3.24	1.77	3.66	2.88
	Change in COHb	90	0.69	1.41				
Smoker	Pre-COHb	52	6.01	2.54	5.45	1.59	6.21	4.79
	Post-COHb	52	6.88	3.16	6.13	1.66	7.07	5.32
	Change in COHb	52	0.87	1.87				
Non-smoker	Pre-COHb	85	2.07	0.76	1.97	1.33	2.10	1.86
	Post-COHb	82	2.42	0.66	2.34	1.28	2.47	2.22
	Change in COHb	82	0.44	0.70				

Table A-20 (cont)

Summary Statistics of COHb Data
Collected at the QMT and TB 8/3 - 13/81

Group	Variable	n	Mean	Standard Deviation	Geometric Mean	Geometric Standard Deviation	95% Confidence Limits of Geometric Mean Upper	Lower
Smoker	Pre-COHb	20	6.80	2.42	6.37	1.47	7.62	5.32
(Bridge)	Post-COHb	20	7.43	2.65	6.81	1.61	8.50	5.44
	Change in COHb	20	0.64	1.45				
Non	Pre-COHb	29	2.35	0.86	2.14	1.35	2.40	1.91
Smoker	Post-COHb	26	2.33	0.32	2.31	1.15	2.45	2.19
(Bridge)	Change in COHb	26	0.33	0.48				
Smoker	Pre-COHb	32	5.51	2.53	4.95	1.63	5.90	4.15
(Tunnel)	Post-COHb	32	6.54	3.43	5.74	1.69	6.93	4.76
	Change in COHb	32	1.03	2.10				
Non-	Pre-COHb	56	1.97	0.69	1.89	1.31	2.04	1.76
Smoker	Post-COHb	56	2.46	0.76	2.36	1.32	2.54	2.19
(Tunnel)	Change in COHb	56	0.48	0.78				
Plaza	Pre-COHb	34	3.41	2.46	2.80	1.82	3.45	2.27
(Tunnel)	Post-COHb	34	3.76	3.22	3.02	1.83	3.73	2.44
	Change in COHb	34	0.35	1.72				
Tunnel	Pre-COHb	51	2.92	1.87	2.49	1.73	2.90	2.13
Interior	Post-COHb	51	3.76	2.21	3.28	1.66	3.78	2.85
	Change in COHb	51	0.84	0.92				

Table A-21

Analysis of Variance (ANOVA) of Personal Log CO
and Log COHb Data Between Groups at the QMT and TB 8/3 - 13/81

		GROUP					
		I = Tunnel vs Bridge		II = Smoker vs Non-smoker		Interaction of I and II	
Variables	d.f.[1]	F[2]	p[3]	F	p	F	p
ln(CO)	(1,111)	5.05	0.03*	2.46	0.12	1.34	0.25
ln (Pre-COHb)	(1,133)	8.34	0.01**	249.75	0.01**	0.99	0.32
ln (Post-COHb)	(1,130)	1.22	0.27	208.34	0.01**	1.91	0.17
ln (Post-COHb)- ln (Pre-COHb)	(1,130)	2.05	0.15	2.80	0.10	0.06	0.81

Table A-22

Analysis of Variance (ANOVA) Test for Differences of Personal
Log CO and Log COHb Data Between Groups at the QMT Interior and Toll Plaza 8/3-7/81

		GROUP					
	III = Tunnel Interior vs Tunnel Exterior			IV = Smoker vs Non-smoker		Interaction of III and IV	
Variables	d.f.[1]	F[2]	p[3]	F	p	F	p
ln(CO)	(1,60)	8.91	0.01**	1.15	0.29	0.14	0.71
ln (Pre-COHb)	(1,79)	8.64	0.01**	153.18	0.01**	2.45	0.12
ln (Post-COHb)	(1,79)	0.14	0.71	100.22	0.01**	2.28	0.14
ln (Post-COHb)- ln (Pre-COHb)	(1,79)	9.47	0.01**	2.61	0.11	0.01	0.90

1 d.f. = degrees of freedom
2) F = F value
3) p = probability
 * = p 0.05
** = p 0.01

Table A-23

Change in COHb Levels (%)
from Preshift to Postshift at the QMT and TB 8/3 - 13/81

Group	Average Change in Log Scale	d.f.	Paired value	p	Ratio of Ave. Post - Preshift COHb	Average Change in %	d.f.	Paired t value	p
Entire Sample	0.17	135	7.49	0.01**	1.19	0.61	135	5.53	0.01**
Bridge	0.12	45	3.81	0.01**	1.13	0.47	45	3.10	0.01**
Tunnel	0.20	89	6.52	0.01**	1.22	0.69	89	4.62	0.01**
Smokers	0.12	51	3.26	0.01**	1.13	0.88	51	3.38	0.01**
Non-smokers	0.20	81	6.78	0.01**	1.22	0.44	81	5.63	0.01**
Bridge									
Smokers	0.07	19	1.36	0.19	1.07	0.64	19	1.96	0.07
Non-smokers	0.16	25	4.05	0.01**	1.17	0.33	25	3.57	0.01**
Tunnel									
Smokers	0.15	31	3.00	0.01**	1.16	1.03	31	2.77	0.01**
Non-smokers	0.22	55	5.59	0.01**	1.25	0.48	55	4.62	0.01**
Tunnel									
Plaza	0.08	33	1.40	0.18	1.28	0.35	33	1.18	0.25
Interior	0.28	50	7.92	0.01**	1.32	0.84	50	6.49	0.01**
Smoker									
Plaza	0.01	9	0.05	.50	1.01	0.70	9	0.73	0.49
Tunnel Int.	0.20	18	4.04	0.01**	1.22	1.02	18	3.82	0.01**
Non-smoker									
Plaza	0.10	23	1.67	0.21	1.11	0.20	23	1.30	0.21
Tunnel Int.	0.32	29	6.57	0.01**	1.38	0.71	29	5.19	0.01**

* = Probability (p) 0.05

** = (p) 0.01

Table A-24

Correlation Between Personal CO and COHb Levels at the QMT and TB 8/3 - 13/81

	VARIABLES								
	Preshift ln(COHb)			Postshift ln(COHb)			Difference between Post & preshift ln(COHb)		
Group	r[1]	p[2]	n[3]	r	p	n	r	p	n
Entire Sample	0.13	0.16	117	0.25	0.01**	114	0.29	0.01**	114
Bridge	0.29	0.05	46	0.28	0.07	43	0.02	0.92	43
Tunnel	0.20								
Smokers	-0.09	0.57	45	0.10	0.50	45	0.33	0.03*	45
Non-smokers	0.16	0.18	70	0.36	0.01	67	0.28	0.02*	67
Bridge									
Smokers	0.48	0.04*	19	0.29	0.23	19	-0.21	0.38	19
Non-smokers	0.45	0.02*	27	0.73	0.01*	24	0.26	0.22	24
Tunnel									
Smokers	-0.27	0.19	26	0.07	0.73	26	0.52	0.01**	26
Non-smokers	0.03	0.86	43	0.30	0.05	43	0.29	0.06	43
Tunnel									
Plaza	0.20	0.33	26	0.35	0.08	26	0.34	0.09	26
Interior	0.06	0.69	40	0.12	0.46	40	0.11	0.48	40

1) = correlation

2) p = probability

3) n = number of samples

* = (p) 0.05

** = (p) 0.01

Table A-25

Listing of Graph Notations and Explanations

Notation	Explanation
A - Sample	Area Sample
P - Sample	Personal Sample
A = 1 Obs.	A = 1 Observation
B = 2 Obs.	B = 2 Observations
Pre - COHb	Preshift COHb
Pos - COHb	Postshift COHb
CH - COHb	Change in Postshift and Preshift COHb levels

TABLE A-26

NO_2 TWA Results (ppm) for Personal Samples Collected at QMT [a, b]

Date	Shift	ID Number	Time On/Off	NO_2 (ug/sample) LOD: 0.1 ug	NO_2 (ppm)
8-4-81	7:00am- 3:00pm	N18-1	6:46am/ 1:54pm	0.3	0.41
8-4-81	7:00am- 3:00pm	N19-1	6:49am/ 1:50pm	1.2	1.66
8-4-81	7:00am- 3:00pm	N20-1	6:50am/ 2:58pm	0.2	0.24
8-4-81	7:00am- 3:00pm	N22-1	6:55am/ 1:58pm	0.2	0.27
8-4-81	7:00am- 3:00pm	N21-1	6:55am/ 3:10pm	0.2	0.24
8-4-81	8:00am- 4:00pm	N23-1	6:58am/ 3:06pm	0.2	0.24
8-5-81	7:00am- 3:00pm	N28-1A	6:40am/ 2:15pm	0.2	0.26
8-5-81	7:00am- 3:00pm	N31-1	6:45am/ 1:40pm	0.2	0.28
8-5-81	7:00am- 3:00pm	N32-1	6:47am/ 3:09pm	0.4	0.46
8-5-81	7:00am- 3:00pm	N33-1A	6:50am/ 2:13pm	0.3	0.39
8-5-81	8:00am- 4:00pm	N24-1A	7:33am/ 4:03pm	0.2	0.23
8-5-81	8:00am- 4:00pm	N37-1	7:53pm/ 3:58pm	0.3	0.36
8-5-81	3:00pm-11:00pm	N13-1A	2:41pm/10:58pm	0.1	0.12
8-5-81	3:00pm-11:00pm	N12-1	2:46pm/10:50pm	0.1	0.12
8-5-81	3:00pm-11:00pm	N7-1	2:50pm/11:08pm	0.1	0.12
8-5-81	3:00pm-11:00pm	N40-1	2:53pm/10:55pm	0.2	0.24
8-5-81	3:00pm-11:00pm	N2-1	3:21pm/11:42pm	0.2	0.23
8-5-81	3:00pm-11:00pm	N26-1	3:43pm/ 9:55pm	0.3	0.35
8-5/6-81	11:00pm- 7:00am	N42-1A	10:45pm/ 6:45am	0.3	0.36
8-6/7-81	11:00pm- 7:00am	N44-1	10:51pm/ 7:20am	0.1	0.12
8-6/7-81	11:00pm- 7:00am	N42-1B	11:10pm/ 7:00am	0.1	0.12
8-6/7-81	11:00pm- 7:00am	N16-1	10:50pm/ 7:05am	0.2	0.23
8-7-81	6:30am- 2:30pm	N45-1	6:15am/ 2:16pm	0.2	0.24
8-7-81	6:30am- 1:30pm	N28-1B	6:35am/ 1:44pm	0.1	0.14
8-7-81	6:30am- 1:30pm	N30-1	6:37am/ 1:46pm	0.1	0.14
8-7-81	7:00am- 3:00pm	N1-1	6:40am/ 3:11pm	0.2	0.23
8-7-81	7:00am- 1:30pm	N46-1	6:45am/ 1:35pm	0.2	0.28
8-7-81	7:00am- 3:00pm	N47-1	6:45am/ 2:25pm	0.2	0.25

TABLE A-26 (cont)

NO_2 TWA Results (ppm) for Personal Samples Collected at QMT [a, b]

Date	Shift	ID Number	Time On/Off	NO_2 (ug/sample) LOD: 0.1 ug	NO_2 (ppm)
8-7-81	7:00am- 3:00pm	N48-1	6:50am/ 3:15pm	0.3	0.34
8-7-81	7:00am- 3:00pm	N29-1	11:35am/ 3:05pm	0.3	0.83
8-7-81	7:00am- 3:00pm	N50-1	6:53am/ 3:12pm	0.2	0.24
8-7-81	7:00am- 3:00pm	N27-1	6:53am/ 2:56pm	0.2	0.24
8-7-81	7:00am- 1:30pm	N33-1B	6:53am/ 1:26pm	0.4	0.50
8-7-81	7:00am- 2:00pm	N39-1	7:04am/ 1:55pm	0.3	0.42
8-7-81	7:30am- 4:00pm	N24-1B	7:33am/ 4:00pm	0.2	0.25
8-7-81	1:30pm- 7:00pm	N28-1C	1:44pm/ 6:45pm	0.2	0.39
8-7-81	2:30pm-10:30pm	N51-1	2:32pm/10:33pm	0.2	0.24
8-7-81	2:30pm-11:00pm	N13-1B	2:35pm/11:07pm	0.2	0.24
8-7-81	3:30pm-11:30pm	N57-1	3:28pm/11:46pm	0.2	0.23
8-7-81	3:30pm-12:00am	N58-1	3:36pm/11:50pm	0.3	0.35
8-7-81	3:30pm-11:30pm	N59-1	3:47pm/11:44pm	0.2	0.24
8-7-81	4:00pm-11:30pm	N60-1	3:50pm/11:42pm	0.3	0.37
8-7-81	4:00pm-12:00am	N61-1	3:51pm/12:05am	0.3	0.35
8-7-81	4:00pm-12:00am	N62-1	3:52pm/11:45pm	0.3	0.37

a) Samples were not blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

b) Flow rate (passive diffusion) for the Palmes tube is 55 mL/hr.[45]

TABLE A-27

NO_2 TWA Results (ppm) for Personal Samples Collected at TB-M Plaza [a, b]

Date	Shift	ID Number	Time On/Off	NO_2 (ug/sample) LOD: 0.1 ug	NO_2 (ppm)
8-10-81	7:00am- 3:00pm	N66-1	6:47am/ 2:40pm	0.1	0.12
8-10-81	7:00am- 3:00pm	N68-1	6:50am/ 3:07pm	<0.1	<0.12
8-10-81	7:00am- 2:00pm	N69-1A	6:53am/ 2:13pm	0.1	0.13
8-10-81	7:00am- 3:00pm	N70-1A	6:55am/ 3:01pm	<0.1	<0.12
8-10-81	6:00am- 2:00pm	N71-1	7:10am/ 1:50pm	<0.1	<0.15
8-10-81	6:00am- 2:00pm	N72-1	7:15am/ 2:55pm	<0.1	<0.13
8-10-81	6:00am- 2:00pm	N73-1	7:20am/ 1:50pm	0.1	0.15
8-10-81	6:00am- 2:00pm	N74-1	7:33am/ 4:00pm	<0.1	<0.11
8-10-81	7:00am- 3:00pm	N75-1	7:40am/ 4:02pm	0.1	0.12
8-10-81	3:00pm-11:00pm	N77-1	2:40pm/10:26pm	<0.1	<0.12
8-10-81	3:00pm-11:00pm	N78-1A	2:40pm/10:25pm	<0.1	<0.12
8-10-81	3:00pm-11:00pm	N79-1A	2:40pm/11:08pm	<0.1	<0.11
8-10-81	3:00pm-11:00pm	N80-1A	2:50pm/10:25pm	<0.1	<0.13
8-10-81	3:00pm-11:00pm	N82-1A	2:50pm/11:05pm	<0.1	<0.12
8-10-81	2:00pm-10:00pm	N83-1	2:58pm/ 9:45pm	<0.1	<0.14
8-11-81	2:00pm-10:00pm	N84-1	2:55pm/ 9:35pm	<0.1	<0.15
8-11-81	3:00pm-11:00pm	N78-1B	2:40pm/11:10pm	<0.1	<0.11
8-11-81	3:00pm-11:00pm	N81-1	2:45pm/10:18pm	<0.1	<0.13
8-11-81	3:00pm-11:00pm	N78-1B	2:52pm/10:20pm	<0.1	<0.13
8-11-81	3:00pm-11:00pm	N85-1A	2:55pm/10:50pm	0.1	0.12
8-11-81	3:00pm-11:00pm	N86-1A	3:00pm/10:50pm	<0.1	<0.12
8-11-81	3:00pm-11:00pm	N87-1	3:05pm/ 9:40pm	<0.1	<0.15
8-11-81	3:00pm-11:00pm	N88-1	3:25pm/11:00pm	<0.1	<0.13
8-11-81	3:00pm-11:00pm	N89-1	3:30pm/10:10pm	<0.1	<0.15
8-11-81	4:00pm-12:00am	N90-1	3:55pm/10:20pm	<0.1	<0.15
8-11-81	4:00pm-12:00am	N91-1	3:40pm/11:40pm	<0.1	<0.12
8-11-81	4:00pm-12:00am	N92-1	3:55pm/10:21pm	<0.1	<0.15
8-11/12-81	5:00pm- 1:00am	N93-1	4:45pm/ 9:15pm	<0.1	<0.22

Table A-27 (cont.)

NO_2 TWA Results (ppm) for Personal Samples Collected at TB-M Plaza [a, b]

Date	Shift	ID Number	Time On/Off	NO_2 (ug/sample) LOD: 0.1 ug	NO_2 (ppm)
8-11/12-81	11:00pm- 7:00am	N95-1A	10:50pm/ 7:05am	<0.1	<0.12
8-11/12-81	11:00pm- 7:00am	N96-1A	10:50pm/ 6:45am	<0.1	<0.12
8-11/12-81	11:00pm- 7:00am	N86-1B	1:15am/ 6:42am	<0.1	<0.18
8-11/12-81	11:00pm- 7:00am	N85-1B	10:55pm/ 6:55am	<0.1	<0.12
8-12/13-81	11:00pm- 7:00am	N85-1C	10:45pm/ 7:10am	<0.1	<0.22
8-12/13-81	11:00pm- 7:00am	N96-1B	10:45pm/ 7:12am	<0.1	<0.11
8-12/13-81	11:00pm- 7:00am	N95-1B	10:50pm/ 7:15am	<0.1	<0.11
8-12/13-81	11:00pm- 7:00am	N86-1C	10:50pm/ 6:35am	<0.1	<0.12
8-13-81	7:00am- 3:00pm	N69-1B	6:30am/ 2:57pm	<0.1	<0.11
8-13-81	7:00am- 3:00pm	N97-1	6:30am/ 3:03pm	<0.1	<0.11
8-13-81	7:00am- 3:00pm	N70-1B	6:35am/ 2:38pm	0.1	0.12
8-13-81	7:00am- 3:00pm	N82-1B	6:35am/ 3:06pm	0.1	0.11
8-13-81	7:00am- 3:00pm	N79-1C	6:40am/ 2:55pm	0.1	0.12
8-13-81	7:00am- 3:00pm	N80-1B	6:45am/ 2:55pm	<0.1	<0.12

a) Samples were not blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

b) Flow rate (passive diffusion) for the Palmes tube is 55 mL/hr.[45]

TABLE A- 28

NO_2 TWA Results (ppm) for Area Samples Collected at QMT & TB-M and TB-B Plazas [a, b]

Date	Shift	Pump Location	Time On/Off	NO_2 (ug/sample) LOD: 0.1 ug	NO_2 (ppm)
8-4-81	7:00am- 3:00pm	QMT:Lane 3	7:10am/ 3:10pm	0.3	0.36
8-5/6-81	11:00pm- 7:00am	QMT:Lane 12	11:50pm/ 7:15am	0.2	0.26
8-5/6-81	11:00pm- 7:00am	QMT:Lane 12	11:45pm/ 7:15am	0.2	0.26
8-6/7-81	11:00pm- 5:00am	QMT:Lane 5	11:50pm/ 5:00am	0.5	1.36
8-7-81	6:00am- 3:00pm	Catwalk N-4	6:15am/ 2:45pm	0.6	0.68
8-7-81	6:00am- 3:00pm	Tunnel Booth 47	6:15am/ 2:45pm	0.3	0.34
8-7-81	3:00pm-11:00pm	Catwalk S-1	2:45pm/ 9:05pm	0.2	0.31
8-7-81	3:00pm-11:00pm	Tunnel Booth 44	2:45pm/ 9:05pm	0.5	0.76
8-7-81	3:00pm-11:00pm	QMT:Lane 13	4:25pm/12:00am	0.3	0.38
8-7-81	3:00pm-11:00pm	QMT:Lane 8	4:29pm/12:00am	0.3	0.39
8-7-81	3:00pm-11:00pm	QMT:Lane 2	4:34pm/12:00am	0.2	0.26
8-10-81	8:00am- 4:00pm	TB-M:Lane 10	8:25pm/ 4:00pm	0.2	0.26
8-10-81	8:00am- 8:00pm	TB-M:Lane 5	8:25am/ 7:45pm	0.2	0.17
8-10-81	1:30pm- 9:30pm	TB-B:Lane 13	1:30pm/ 9:30pm	0.2	0.32
8-10-81	1:30pm- 9:30pm	TB-B:Lane 15	1:35pm/ 9:25pm	0.1	0.17
8-10-81	1:30pm- 9:30pm	TB-B:Lane 16	1:40pm/ 9:26pm	0.3	0.50
8-10-81	1:30pm- 9:30pm	TB-B:Lane 2	1:49pm/ 9:17pm	0.3	0.53
8-10-81	1:30pm- 9:30pm	TB-B:Lane 1	1:52pm/ 9:15pm	0.1	0.18
8-11-81	1:00am- 7:30am	TB-M:Lane 12	12:50am/ 7:25am	0.2	0.29
8-13-81	9:00am- 5:00pm	TB-B:Lane 15	9:05am/ 4:55pm	0.1	0.12
8-13-81	9:00am- 5:00pm	TB-B:Lane 14	9:05am/ 4:58pm	0.1	0.12
8-13-81	9:00am- 5:00pm	TB-B:Lane 10	9:15am/ 5:02pm	0.2	0.25
8-13-81	9:30am- 5:00pm	TB-B:Lane 2	9:30am/ 5:07pm	0.2	0.25

a) Samples were not blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within $\pm$ 2% of actual values.

b) Flow rate (passive diffusion) for the Palmes tube is 55 mL/hr.[45]

TABLE A -29

PAH TWA Results (mg/m^3) for Personal Samples Collected at QMT and TB-M (a, b, c, d)

Date	Shift	ID Number	Time On/Off	Cyclohexane (mg/sample)	Solubles (mg/m^3)
8-3-81	3:00pm-11:00pm	PQ 13-1	4:25pm/10:45pm	<0.02	<LOD
8-4-81	8:00am- 4:00pm	PQ 25-1	7:35am/ 3:53pm	<0.02	<LOD
8-5-81	7:00am- 3:00pm	PQ 22-1	6:35am/ 3:12pm	<0.02	<LOD
8-5-81	7:00am- 3:00pm	PQ36-1	7:50am/ 3:12pm	<0.02	<LOD
8-5/6-81	11:00pm- 7:00am	PQ 40-1	10:55pm/11:33pm	<0.02	<LOD
8-6/7-81	11:00pm- 7:00am	PQ 16-1	12:20am/ 7:05am	0.02	0.026
8-6/7-81	11:00pm- 7:00am	PQ 17-1	1:00am/ 7:08am	0.02	0.029
8-7-81	7:00am- 3:00pm	PQ 32-1	6:29am/ 1:42pm	0.04	0.049
8-7-81	7:00am- 3:00pm	PQ 47-1	6:45am/ 2:25pm	0.72	0.824
8-13-81	7:00am- 3:00pm	PT 100-1	6:55am/ 2:50pm	<0.02	<LOD (e)
8-13-81	7:00am- 3:00pm	PT 101-1	7:40am/ 2:30pm	0.02	0.026 (e)

a) Samples were not blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

b) Flow rate for Dupont P-4000 pumps was 1.9 Lpm.

c) <LOD = less than the limit of detection.

d) Benz(a)anthracene (B(a)A), benzo(a)pyrene (B(a)P), and chrysene levels were <LOD of 0.05, 0.05, and 0.12 ug/sample, respectively.

Pyrene values (82%) that were at or above the LOD ranged from 0.0002 to 0.0008 mg/m^3 with an arithmatic mean of 0.0003 mg/m^3.

Fluoranthene values (3) that were at or above the LOD ranged from 0.0001 to 0.0003 mg/m^3 with an arithmatic mean of 0.0002 mg/m^3.

e) Benzene solubles.

TABLE A- 30

PAH TWA Results (mg/m^3) for Area Samples Collected at QMT (a, b, c, d)

Date	Shift	Pump Location	Time On/Off	Cyclohexane Solubles (mg/ Sample)	Cyclohexane Solubles (mg/m^3)
8-3-81	3:00pm-11:00pm	QMT:Lane 3/5	4:43pm/11:25pm	<0.02	<LOD
8-3-81	3:00pm-11:00pm	QMT:Lane 7	4:40pm/11:18pm	0.04	0.053
8-4-81	7:00am- 3:00pm	QMT:Lane 3	7:10am/ 2:25pm	0.02	0.024
8-4-81	7:00am- 3:00pm	QMT:Lane 7	7:22am/ 3:15pm	0.18	0.200
8-5-81	7:00am- 3:00pm	QMT:Lane 5	7:10am/ 4:57pm	0.04	0.036
8-5-81	7:00am- 3:00pm	QMT:Lane 7	7:23am/ 3:45pm	0.02	0.021
8-5-81	2:00pm-10:00pm	Catwalk S-1	2:10pm/10:10pm	0.12	0.132
8-5/6-81	5:00pm- 1:00am	QMT:Lane 7	5:00pm/ 1:00am	<0.02	<LOD
8-5/6-81	5:00pm- 1:00am	QMT:Lane 3	5:05pm/ 1:28am	<0.02	<LOD
8-5/6-81	5:00pm- 1:00am	QMT:Inside Booth 7	5:10pm/ 1:05am	<0.02	<LOD
8-5/6-81	11:00pm- 7:00am	QMT:Lane 12	12:05am/ 7:15am	<0.02	<LOD
8-7-81	6:00am- 2:00pm	QMT:Catwalk N-4	6:10am/ 2:11pm	0.18	0.200
8-7-81	2:00pm-10:00pm	QMT:Catwalk S-1	2:25pm/ 9:05pm	0.08	0.110
8-7-81	4:00pm-12:00am	QMT:Lane 13	4:22pm/12:00am	0.04	0.046

a) Samples were not blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

b) Flow rate for Dupont P-4000 pumps was 1.9 Lpm.

c) <LOD = Less than the limit of detection.

d) B(a)A and B(a)P levels were <LOD. One chrysene value was at the LOD; all others were <LOD.

Pyrene values ranged from 0.0002 to 0.0004 mg/m^3 with an arithmatic mean of 0.0003 mg/m^3.

Fluoranthene values (79%) that were at or above the LOD ranged from 0.0001 to 0.0002 mg/m^3 with an arithmatic mean of 0.0001 mg/m^3.

TABLE A-31

PAH TWA Results (mg/m^3) for Area Samples Collected at TB-M and TB-B Plazas [a, b, c, d]

Date	Shift	Pump Location	Time On/Off	Benzene Solubles (mg/Sample)	Benzene Solubles (mg/m^3)
8-10-81	8:00am- 4:00pm	TB-M:Lane 5	8:25am/ 7:45pm	0.04	0.030
8-10-81	8:00am- 4:00pm	TB-M:Lane 10	8:28am/ 3:55pm	0.02	0.020
8-10-81	3:00pm-11:00pm	TB-M:Lane 2	3:40pm/10:50pm	<0.02	<LOD
8-10-81	1:00pm- 9:00pm	TB-B:Lane 15	1:35pm/ 9:25pm	0.04	0.045
8-10-81	1:00pm- 9:00pm	TB-B:Lane 16	1:40pm/ 9:26pm	0.02	0.023
8-10-81	1:00pm- 9:00pm	TB-B:Lane 2	1:47pm/ 9:17pm	0.04	0.047
8-11-81	5:00pm- 1:00am	TB-M:Lane 7/8	5:10pm/ 8:10pm	<0.02	<LOD
8-11/12-81	11:00pm- 7:00am	TB-M:Lane 3/5	11:40pm/ 7:00am	<0.02	<LOD
8-11/12-81	12:00am- 8:00am	TB-M:Lane 12/13	12:05am/ 7:25am	0.02	0.024
8-13-81	8:00am- 4:00pm	TB-M:Lane 15	7:55am/ 3:30pm	0.06	0.069
8-13-81	8:00am- 4:00pm	TB-M:Lane 2	7:43am/ 3:43pm	0.06	0.066
8-13-81	8:00am- 4:00pm	TB-M:Lane 14	8:05am/ 3:37pm	0.06	0.070
8-13-81	9:00am- 5:00pm	TB-B:Lane 15	8:55am/ 4:55pm	0.04	0.040
8-13-81	9:00am- 5:00pm	TB-B:Lane 14	9:03am/ 4:58pm	<0.02	<LOD
8-13-81	9:00am- 5:00pm	TB-B:Lane 3	9:20am/ 5:05pm	0.04	0.045
8-13-81	9:00am- 5:00pm	TB-B:Lane 2	9:23am/ 5:08pm	0.04	0.045

a) Samples were not blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within $\pm$ 2% of actual values.

b) Flow rate for Dupont P-4000 pumps was 1.9 Lpm.

c) <LOD = Less than the limit of detection.

d) All B(a)A, B(a)P, and chyrsene levels were <LOD.

Pyrene values (43%) that were at or above the LOD ranged from 0.0002 to 0.0009 mg/m^3 with an arithmatic mean of 0.0005 mg/m^3.

Fluoranthene values ranged from 0.0001 to 0.0003 mg/m^3 with an arithmatic mean of 0.0002 mg/m^3.

TABLE A-32

Lead, Iron, and Aluminum TWA Results (mg/m^3) for Personal Samples Collected at QMT and TB-M [a, b, c, d]

Date	Shift	ID Number	Time On/Off	LEAD (e) ug	LEAD (e) mg/m^3	IRON (f) ug	IRON (f) mg/m^3
8-5-81	7:00am- 3:00pm	M4-1	8:02am/ 3:11pm	<4	<LOD	3	0.005
8-5/6-81	11:00pm- 7:00am	M41-1A	12:25am/ 6:08am	<4	<LOD	3	0.006
8-6/7-81	11:00pm- 7:00am	M43-1	3:00am/ 6:55am	10	0.028	6	0.017
8-6/7-81	11:00pm- 7:00am	M41-1B	10:40pm/ 7:08am	<4	<LOD	2	0.003
8-7-81	7:00am- 3:00pm	M46-1	6:45am/ 1:35pm	<4	<LOD	4	0.007
8-7-81	7:00am- 3:00pm	M39-1	7:04am/ 1:55pm	5	0.008	15	0.024
8-10-81	7:00am- 3:00pm	M70-1	6:55am/ 3:01pm	<4	<LOD	3	0.004
8-10-81	7:00am- 3:00pm	M74-1	7:33am/ 4:02pm	6	0.008	4	00.005
8-11/12-81	5:00pm- 1:00am	M94-1	4:40pm/ 1:00am	<4	<LOD	5	0.007
8-13-81	7:00am- 3:00pm	M101-1	7:43am/ 2:30pm	<4	<LOD	3	0.005

a) Samples were blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

b) Flow rate = 1.5 Lpm.

c) All aluminum sample values were below the limit of detection, 10 ug/sample.

d) <LOD = less than the limit of detection.

e) Lead limit of detection = 4 ug/sample.

f) Iron limit of detection = 2 ug/sample.

TABLE A-33

Lead, Iron, and Aluminum TWA Results (mg/m^3) for Area Samples Collected at QMT, TB-M, and TB-B [a, b, c, d]

Date	Shift	Pump Location	Time On/Off	LEAD (e) ug	LEAD (e) mg/m^3	IRON (f) ug	IRON (f) mg/m^3
8-3-81	4:00pm-12:00am	QMT:Lanes 3/5	4:43pm/11:25pm	4.9	0.008(*)	5.9	0.010(*)
8-3-81	4:00pm-12:00am	QMT:Lane 7	4:40pm/11:18pm	5.0	0.008	5.0	0.008
8-4-81	7:00am- 3:00pm	QMT:Lane 3	7:10am/ 2:25pm	14.0	0.020	5.0	0.008
8-4-81	7:00am- 3:00pm	QMT:Lane 7	7:22am/ 3:15pm	3.6	0.005(*)	1.4	0.002(*)
8-5-81	7:00am- 3:00pm	QMT:Lane 5	7:15am/ 4:56pm	14.0	0.016	6.0	0.007
8-5-81	7:00am- 3:00pm	QMT:Lane 7 (g)	7:20am/ 3:43pm	18.0	0.024	12.0	0.016
8-5-81	2:00pm-10:00pm	QMT:Catwalk S-1	2:10pm/10:10pm	17.0	0.024	12.0	0.017
8-5-81	4:00pm-12:00am	QMT:Booth 7	5:10pm/12:15am	<4.0	<LOD	<2.0	<LOD
8-5-81	5:00pm- 1:00am	QMT:Lane 13	5:05pm/ 1:28am	<4.0	<LOD	5.0	0.007
8-6-81	6:00am- 2:00pm	QMT:Catwalk N-4	6:10am/ 1:00pm	<4.0	<LOD	3.0	0.005
8-7-81	2:00pm-10:00pm	QMT:Catwalk S-1	2:25pm/ 9:03pm	9.0	0.015	8.0	0.013
8-7-81	4:00pm-12:00am	QMT:Lane 13	4:22pm/12:00am	<4.0	<LOD	5.0	0.007
8-7-81	4:00pm-12:00am	QMT:Lane 2	4:43pm/12:03am	10.0	0.015	6.0	0.009
8-10-81	8:00am- 4:00pm	TB-M:Lane 5	8:25am/ 4:00pm	2.8	0.004(*)	5.2	0.008(*)
8-10-81	8:00am- 4:00pm	TB-M:Lane 10	8:28am/ 3:55pm	6.0	0.009	4	0.006
8-10-81	2:00pm-10:00pm	TB-B:Lane 15	1:35pm/ 9:25pm	2.8	0.004(*)	4	0.006(*)
8-10-81	2:00pm-10:00pm	TB-B:Lane 16	1:40pm/ 9:26pm	6.0	0.009	6	0.009
8-10-81	2:00pm-10:00pm	TB-B:Lane 2	1:48pm/ 9:17pm	7.0	0.010	5	0.007
8-10-81	2:00pm-10:00pm	TB-B:Lane 1	1:51pm/ 9:15pm	<4.0	<LOD	6	0.009
8-11-81	4:00pm-12:00am	TB-M:Lane 7	5:00pm/11:55pm	<4.0	<LOD	3	0.005
8-11/12-81	11:00pm- 7:00am	TB-M:Lane 3/5	11:35pm/ 7:00am	<4.0	<LOD	3	0.004

TABLE A- 33 (cont)

Lead, Iron, and Aluminum TWA Results (mg/m^3) for Area Samples Collected at QMT, TB-M, and TB-B (a, b, c, d)

Date	Shift	Pump Location	Time On/Off	LEAD (e) ug	LEAD (e) mg/m^3	IRON (f) ug	IRON (f) mg/m^3
8-11/12-81	11:00pm- 7:00am	TB-M:Lane 12/5	12:05am/ 7:25am	10	0.015	4	0.006
8-13-81	7:00am- 3:00pm	TB-M:Lane 14	7:55am/ 3:57pm	13	0.018	5	0.007
8-13-81	7:00am- 3:00pm	TB-M:Lane 15	7:55am/ 3:30pm	12	0.018	5	0.007
8-13-81	8:00am- 4:00pm	TB-B:Lane 15	8:55am/ 4:55pm	7	0.010	8	0.011
8-13-81	8:00am- 4:00pm	TB-B:Lane 14	9:03am/ 4:58pm	8	0.011	6	0.008
8-13-81	8:00am- 4:00pm	TB-B:Lane 14	9:18am/ 4:55pm	6	0.009	5	0.007
8-13-81	8:00am- 4:00pm	TB-B:Lane 3	9:18am/ 5:05pm	6.1	0.009(*)	4.4	0.006(*)
8-13-81	8:00am- 4:00pm	TB-B:Lane 2	9:23am/ 5:07pm	9	0.130	8	0.011

a) Samples were blank corrected. Data have not been corrected for temperature and pressure variation; maximum deviation would be within ± 2% of actual values.

b) Flow rate = 1.5 Lpm.

c) All aluminum sample values were below the limit of detection, 10 ug/sample.

d) LOD = less than the limit of detection.

*) Preliminary metal scan conducted by DPSE, NIOSH.

e) Lead limit of detection = 4 ug/sample.

f) Iron limit of detection = 2 ug/sample.

g) Flow rate = 1.9 Lpm.

Table A-34

Asbestos Area Sample
Results Collected at QMT and TB[a,b]

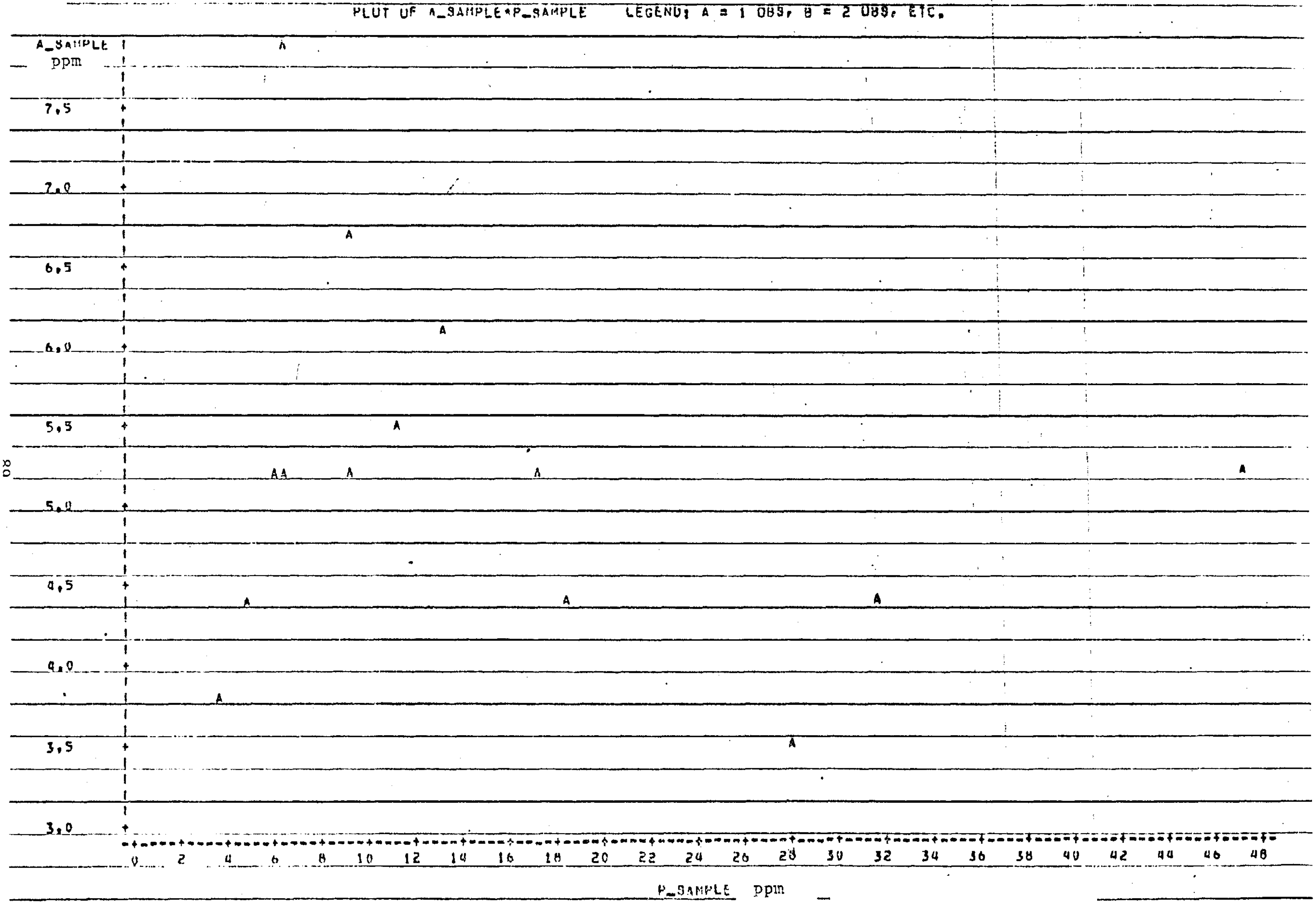
Date	Location	Shift	Total Sampling Time (Min)	Flow Rate (Lpm)	Filter Number	Asbestos Conc. (Fibers/cc)
8/ 5/81	QMT-Lane 7	5 p.m.- 1 a.m.	480 min.	1.5	QMT-18	0.005
8/ 5/81	QMT-Lane 12	12 a.m.- 7 a.m.	450 min.	1.5	QMT-12	0.006
8/13/81	TB-M-Lane 2[c]	8 a.m.- 4 p.m.	493 min.	1.5	TB-55	0.002
8/13/81	TB-B-Lane 10[c]	9 a.m.- 5 p.m.	467 min.	1.5	TB-52	0.001

a) Fiber concentration/cc = $\frac{\text{(sample average count - blank average count) (855 mm}^2\text{)}}{\text{(field area mm}^2\text{) (flow rate cc/min) (sampling time, min)}}$

b) Samples were not blank corrected.

c) TB-M indicates Triborough Bridge - Manhattan Toll Plaza
TB-B indicates Triborough Bridge - Bronx Toll Plaza

Figure A-1 - GRAPH OF AREA CO vs PERSONAL CO



* SEE TABLE 26

Figure A-2- GRAPH OF AREA CO vs PREHSIFT COHb

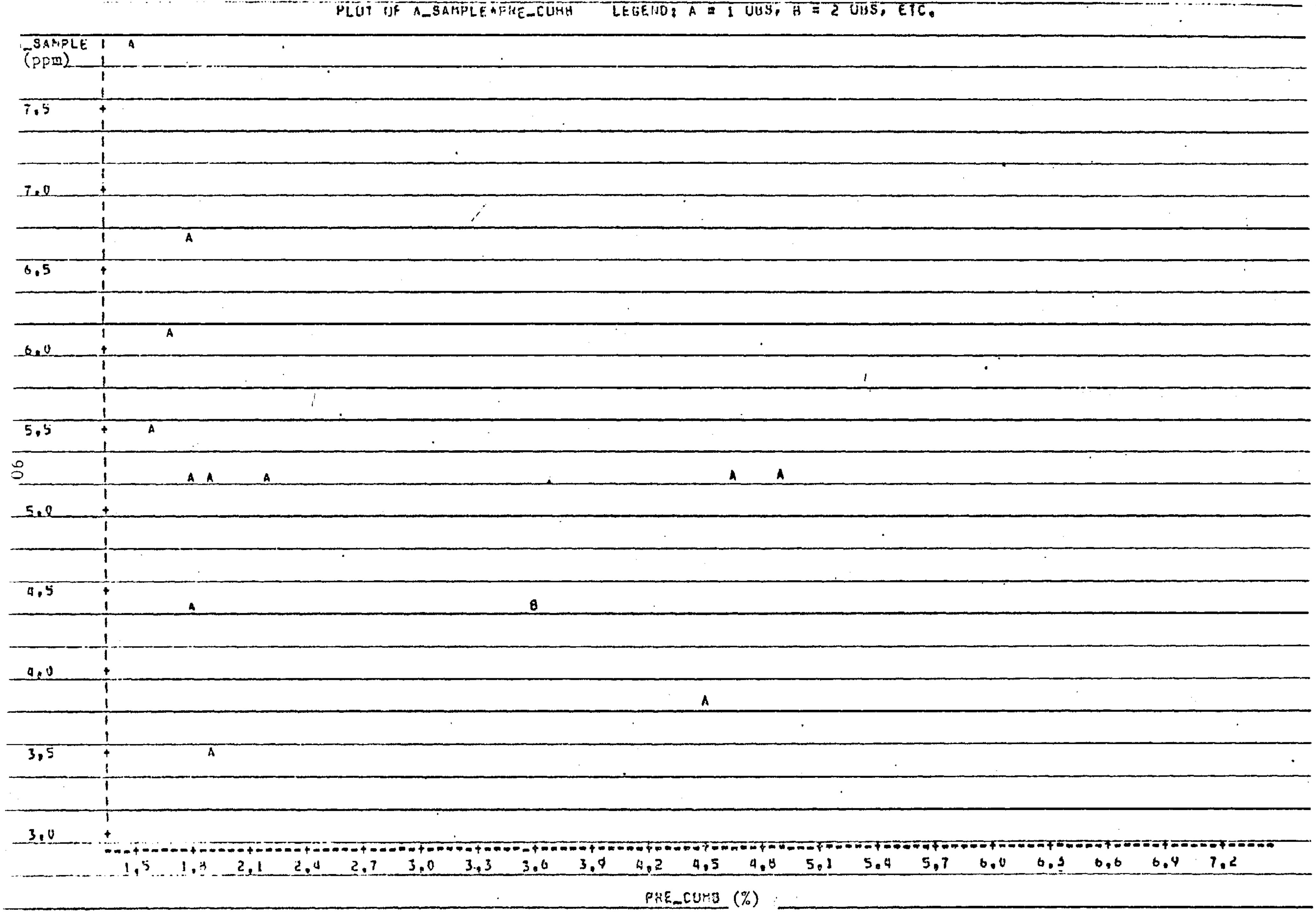


Figure A-3 - GRAPH OF AREA CO VS POSISHIFT COHB

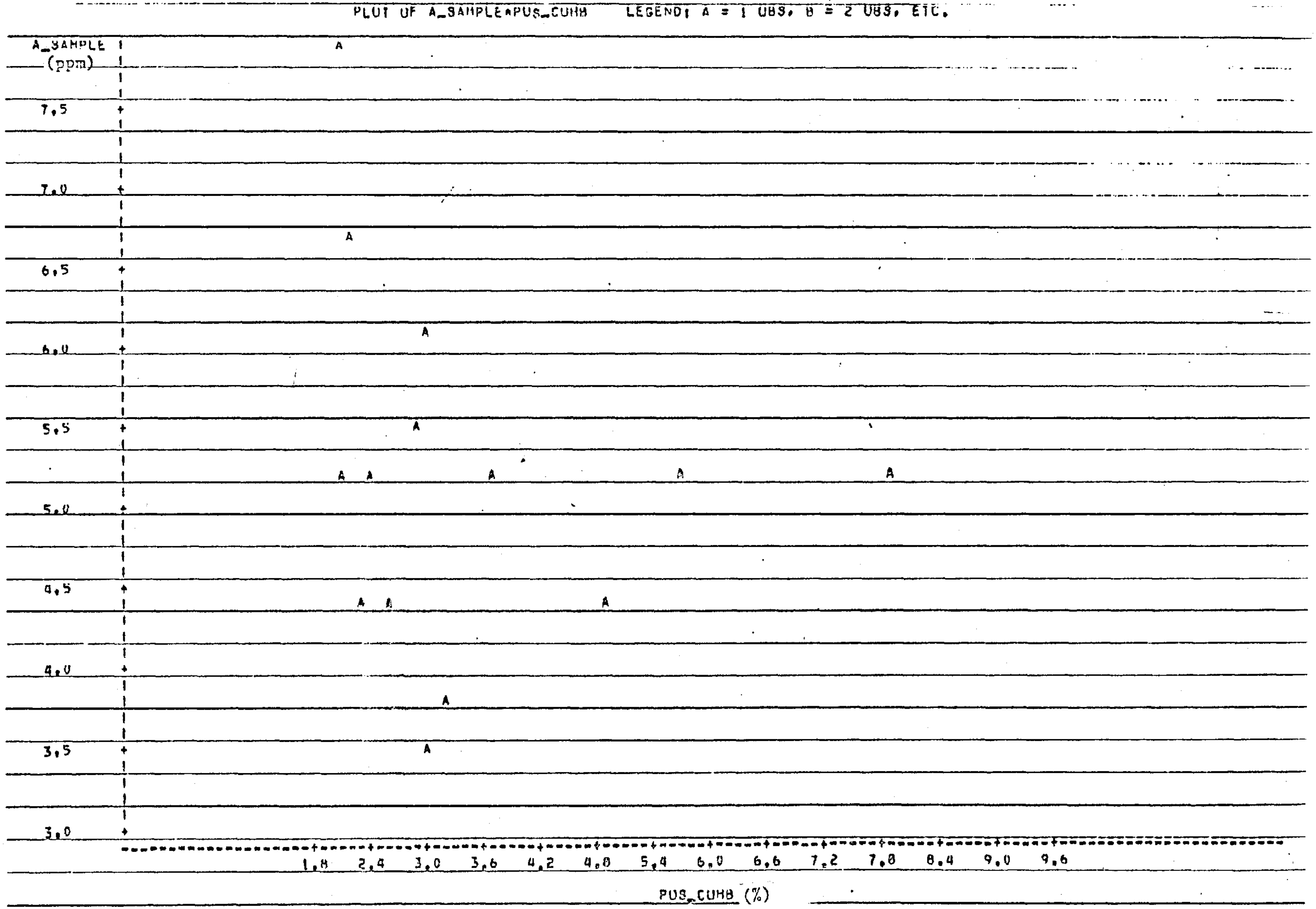


Figure A-4- GRAPH OF AREA CO vs CHANGE IN POST AND PRE-SHIFT COHb LEVELS

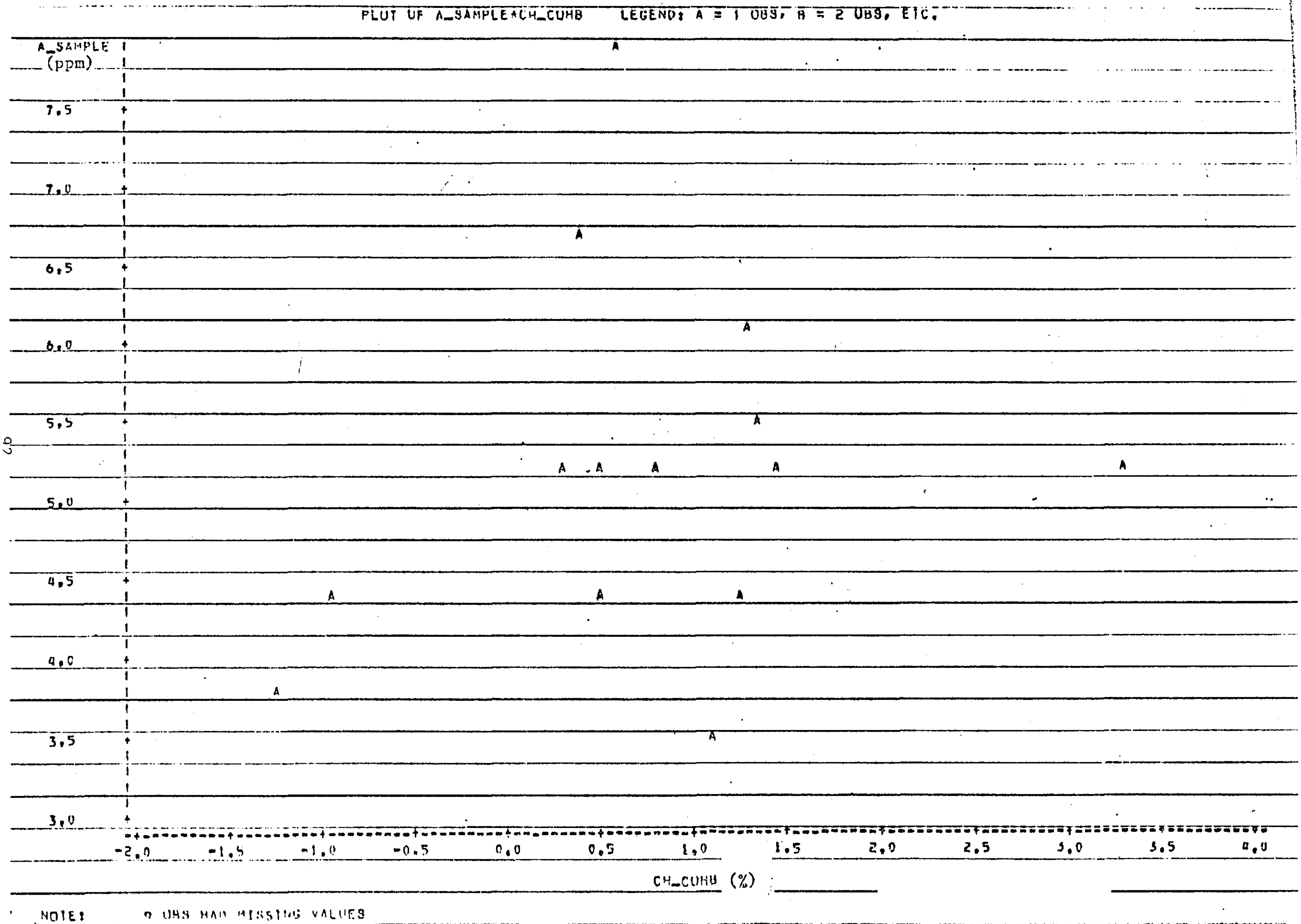


Figure A-5- GRAPH OF PERSONAL CO vs PRESHIFT COHb

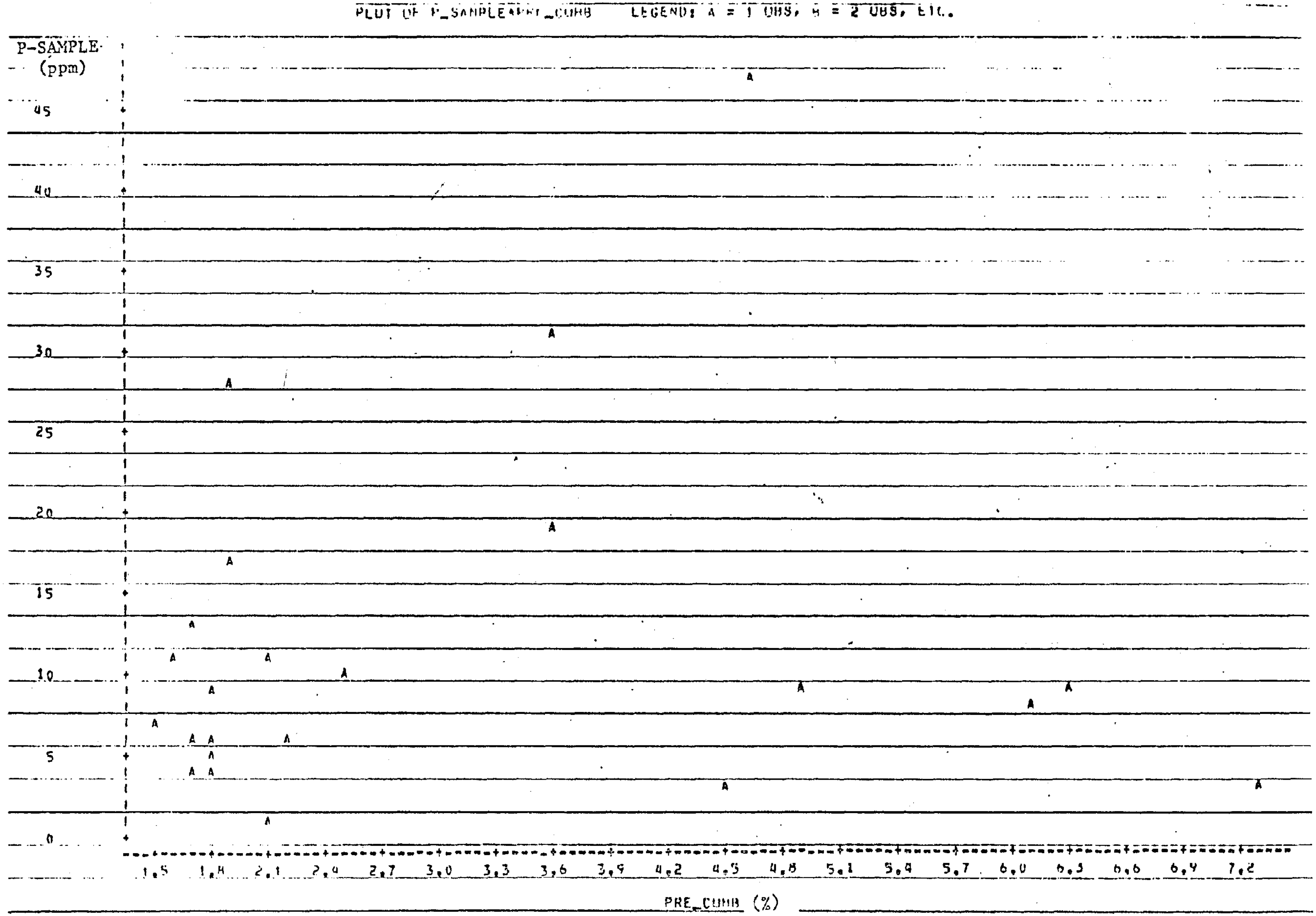


Figure A-6- GRAPH OF PERSONAL CO vs POSTSHIFT COHb

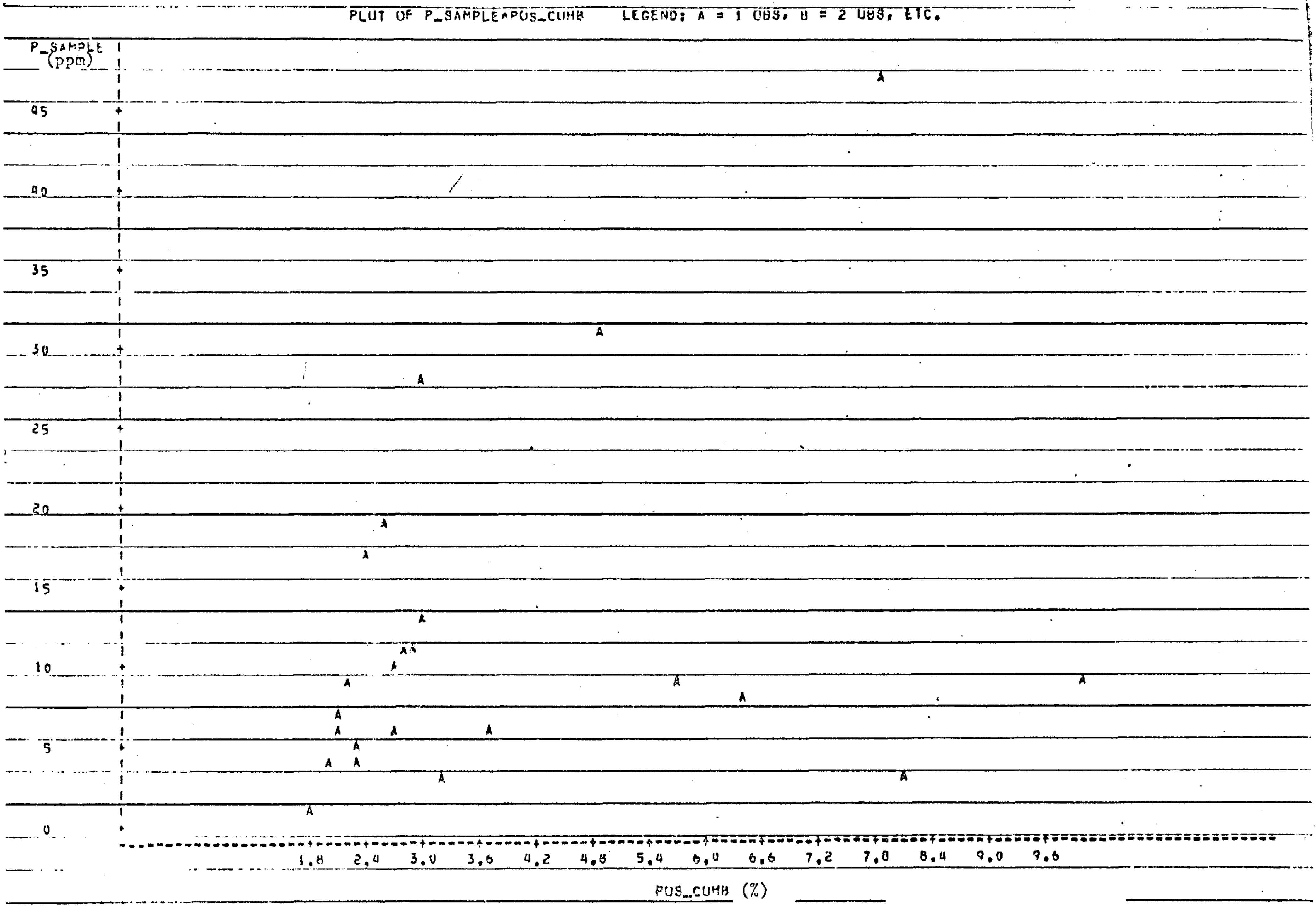


Figure A-7 GRAPH OF PERSONAL CO vs CHANGE IN POST AND PRE-SHIFT COHb LEVELS

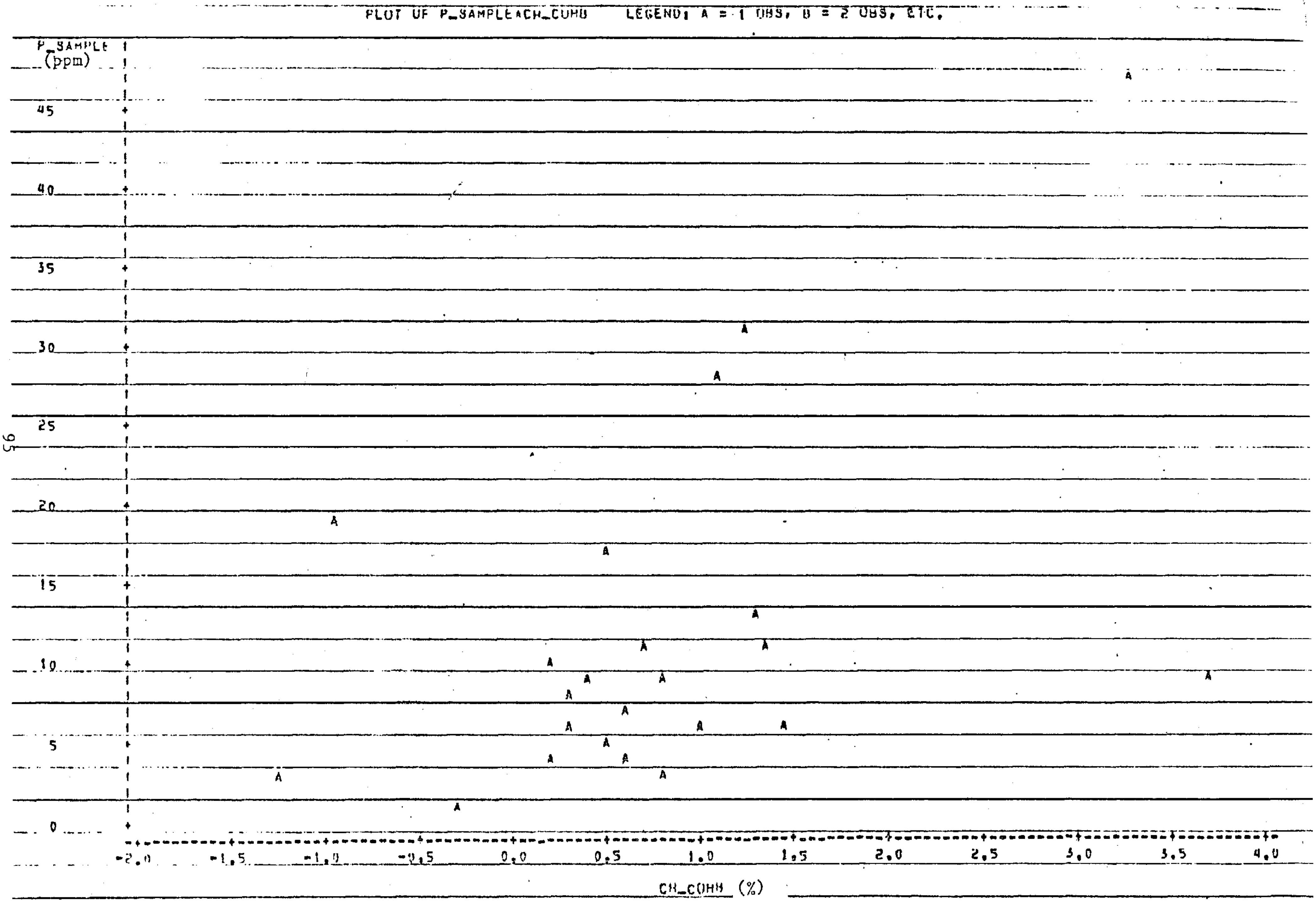
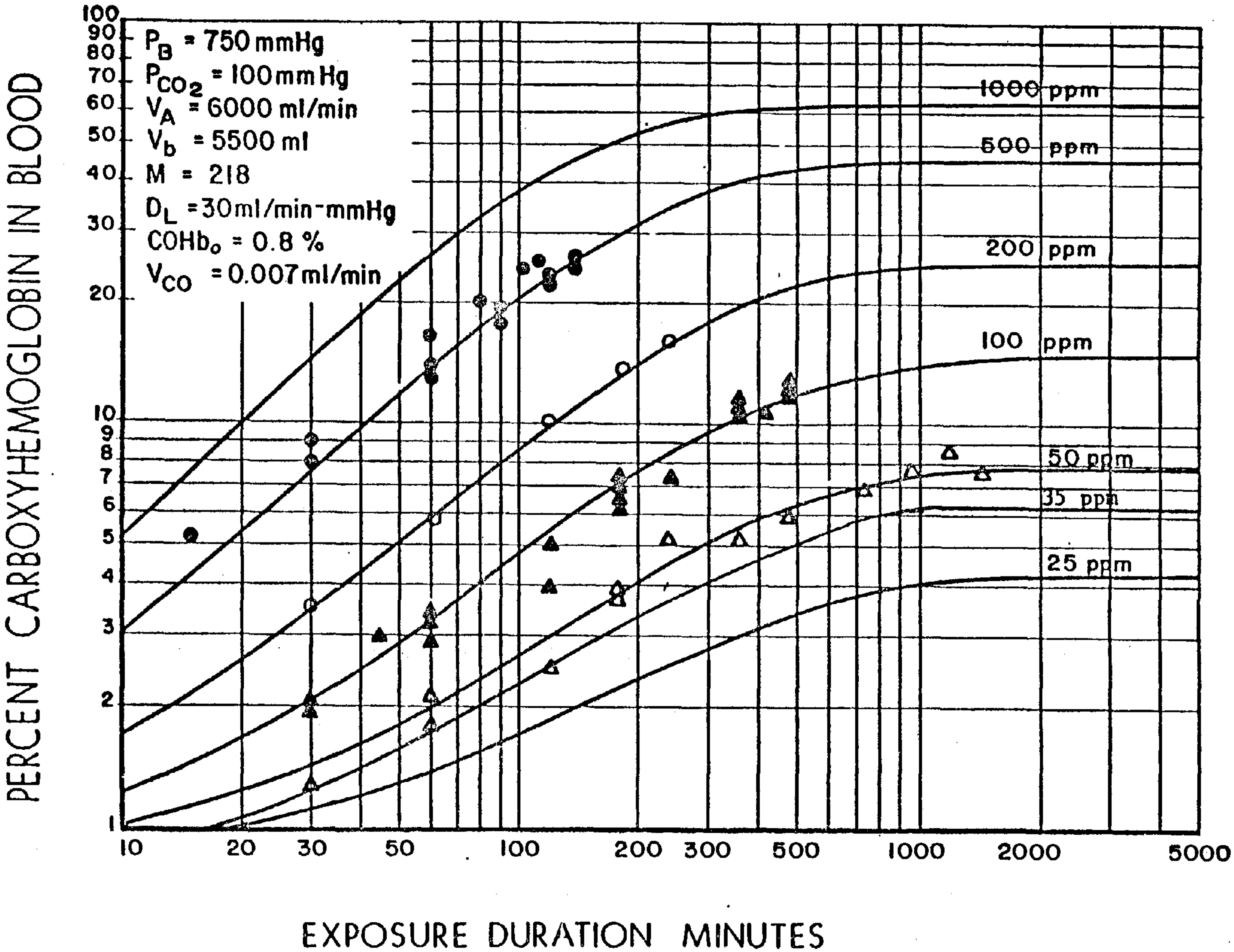


Figure A-8

ABSORPTION OF CARBON MONOXIDE



Stewart, R. D., et al: Experimental Human Exposure to Carbon Monoxide. Arch. Environ. Health. 21:154-164, 1970.

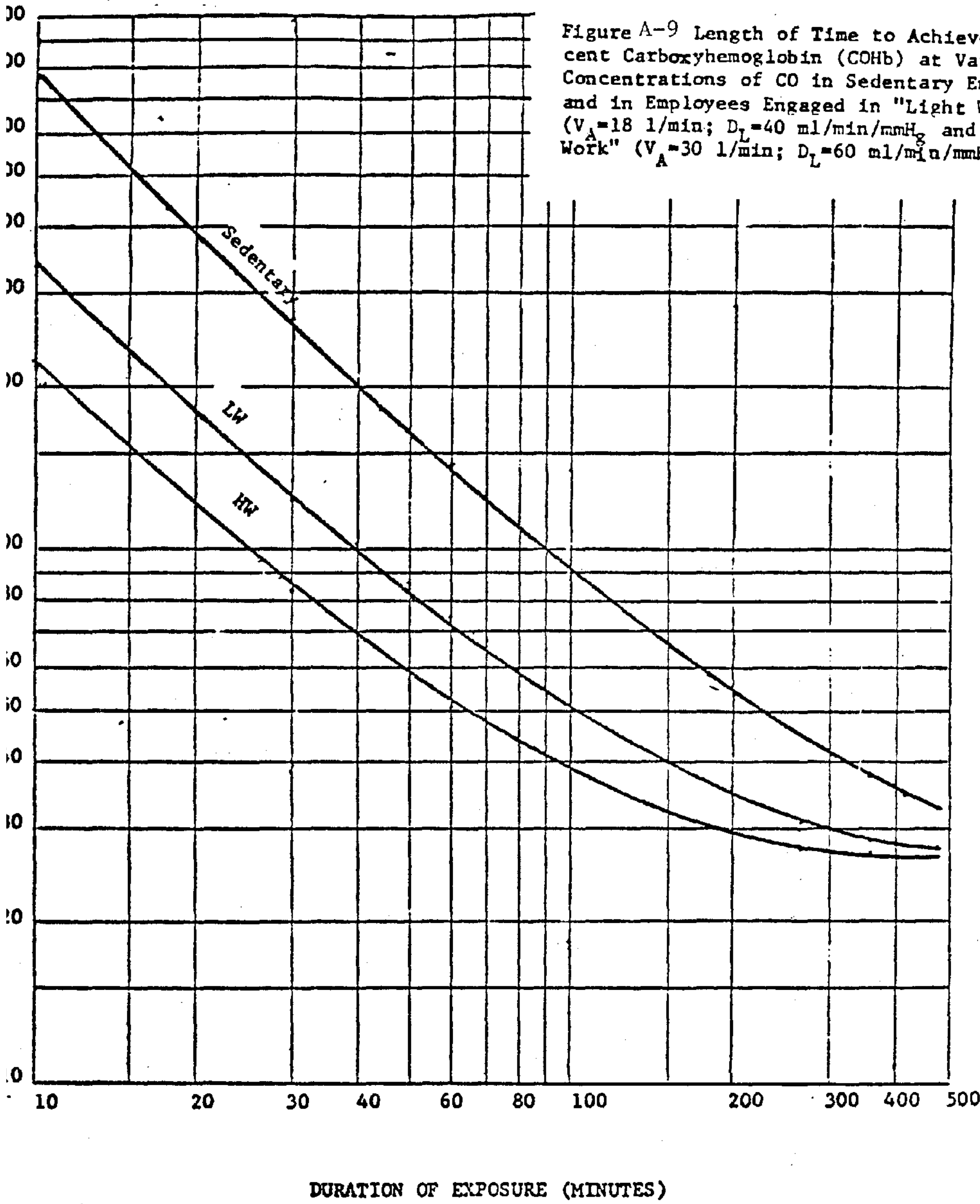


Figure A-9 Length of Time to Achieve 5 percent Carboxyhemoglobin (COHb) at Various Concentrations of CO in Sedentary Employees and in Employees Engaged in "Light Work" (V_A=18 l/min; D_L=40 ml/min/mmHg and "Heavy Work" (V_A=30 l/min; D_L=60 ml/min/mmHg).

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